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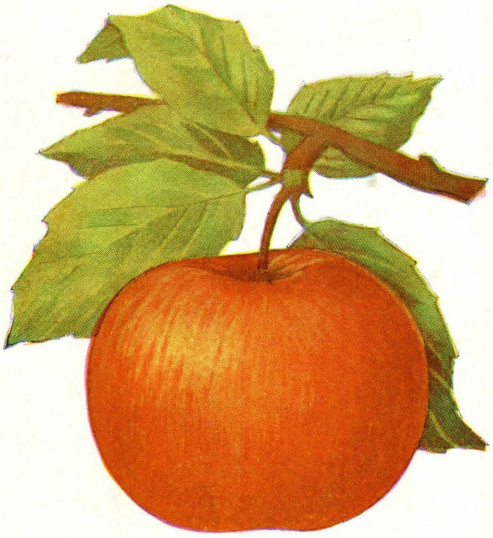
Spraying Program

and

Pest Control for Fruit Crops

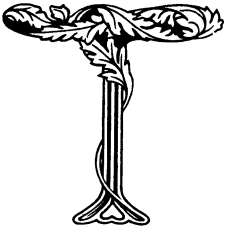


OHIO
AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio

Spray recommendations are constantly being revised. If your bulletin is more than two years old, contact your county agent for the latest edition.

Spraying Program

Up-to-Date Information on Insecticides and Fungicides And Recommendations for Their Use in the Control of Insects and Diseases Affecting Ohio Fruit Crops



Prepared By
Specialists in Entomology, Plant Pathology, and Horticulture
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SPRAYING PROGRAM

and Pest Control for Fruit Crops

THE MANY orchards in Ohio represent a wide range in conditions such as: age of trees, location, cultural practices, varieties, and susceptibility to insects and diseases. A spray program cannot be formulated that will meet the requirements of each individual orchard. Seasonal variations, orchard cultural practices, and general environmental conditions largely govern the severity of both disease and insect outbreaks. For these reasons some orchards may require an extreme spray program to control pests, while in others during the same season, such a program may not be necessary.

Changes in spraying procedure become necessary from year to year. This is due in part to the ever-changing conditions concerning the pests against which the treatments are directed, and in part to the development of new materials and to new information concerning older ones. Rapid advances are being made in perfecting spraying materials, and new ones continue to appear.

This bulletin discusses the principal spray materials now offered for sale, and suggests proper combinations that will best control insects and diseases without causing spray injury to the fruit and foliage. It has been prepared after considerable discussion of the effectiveness and safety of the materials and combinations suggested; these having been thoroughly tested and approved. Formulas and dilution strengths are based on 100 gallons of spray as a unit. For small plantings not requiring that much material, a conversion table is given on page 22.

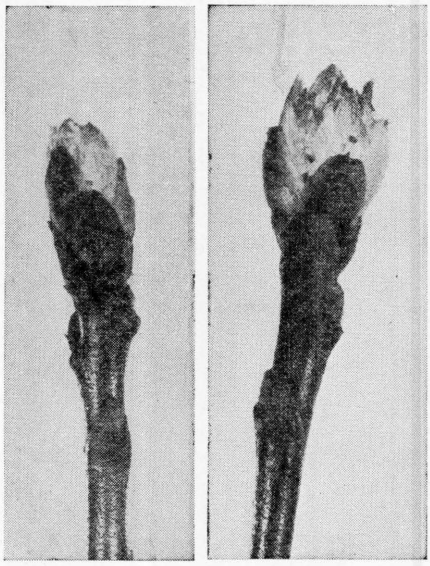
The three main considerations in successful spraying are: *correct timing, thorough application,* and the *use of proper materials.* These are the "big three" responsible for success in spraying, and if any one is neglected the structure falls, for without all three of them success cannot be attained.

The Ohio Spray Service

The Ohio Spray Service is entirely informational, and deals largely with the *timing* of sprays. Its chief object is to help the grower to adapt his spray program to the seasonal requirements.

The information is distributed by the Extension Service of the College of Agriculture, and is of two general types: (1) letters, and (2) radio broadcasts. The information upon which recommendations are based is collected from all parts of the state and assembled at Columbus. Suggestions on the necessary spraying procedure are then sent to the county agents, who in turn notify every fruit grower on their mailing lists.

Each fruit grower is sent a letter for each apple spray. No further information is issued for the *dormant spray.* For the *pre-blossom*



(a) (b)

Fig. 1.—(a) Green tip stage; (b) Delayed dormant stage.

sprays, a letter is mailed in advance giving all the necessary information, except the *time* of application. The *place* and *hour* of radio broadcasts are announced in this second letter.

The *calyx spray* is timed by the fall of the petals and no further information is necessary than that contained in the spray letter. The dates for applying the *cover sprays* are given in letters sent to the fruit growers; the time for spraying varies for the different fruit sections. These spray letters are supplemented by staggered weekly radio broadcasts given over several radio stations.

Every fruit grower in Ohio is entitled to receive the spray service letters. This service is free. Apply to the county agent in your county.

Spray Programs for Control of Insects and Diseases

The Apple Spray Program and Distribution of Principal Apple Pests

One of the reasons that a general apple spray program for Ohio must be somewhat complicated is the peculiar and unequal distribution of some diseases and insects. Scab is general throughout the state. For this disease sulfur or Fermate sprays are recommended.

Brooks spot, blotch, and bitter rot are confined largely to the southern apple growing section. For their control, Fermate, or in its absence, bordeaux mixture is the most effective spray. Scale insects, red mite, codling moth, flea-weevil, and curculio are generally distributed. Red bug and apple maggot are troublesome principally in northeastern Ohio.

Apple scab, codling moth and red mite are the major apple pests in Ohio orchards. For apple orchards in which codling moth is *not* a serious problem, the schedule of cover sprays on page 5 or 6 should be adequate. For orchards in which codling moth has *not* been controlled by a complete schedule of lead arsenate sprays, the program on page 7, which carries DDT spaced at relatively close intervals, will be needed. Selection of the schedule to be followed depends on whether codling moth has been difficult to control.

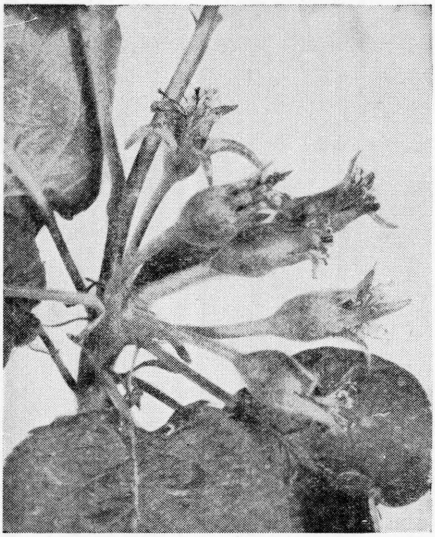


Fig. 2.—Ten days after petal-fall.

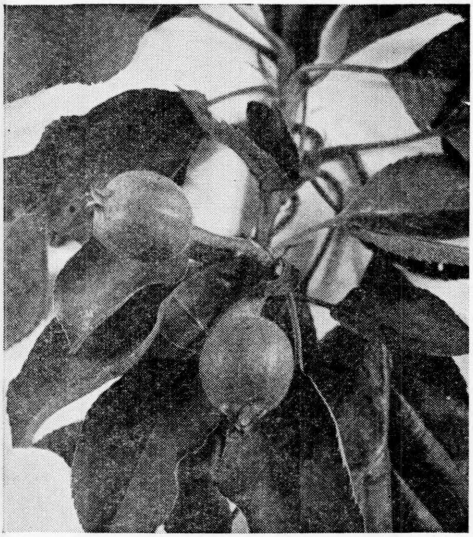


Fig. 3.—Three to four weeks after petal-fall.

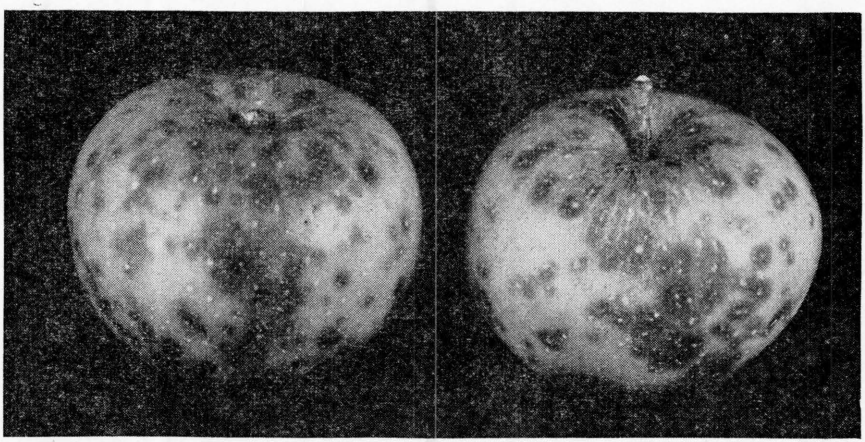


Fig 4.—Apples infested with San Jose scale.

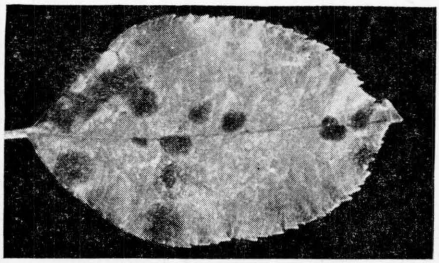


Fig. 5.—Apple scab on leaf.

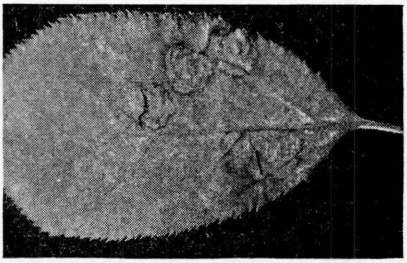


Fig. 6.—Black rot (frog-eye).

EARLY SEASON APPLE SPRAY PROGRAM — ALL ORCHARDS

The spray schedules are divided into periods numbered 1 to 6, and the individual sprays of each are designated by letters, a, b, c, and d. (For small scale needs see Conversion Table on page 22.)

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
1 Dormant In spring when buds are dormant, or in the "green tip" stage. (See Fig. 1.)	Oil emulsion carrying 3% oil *or* Miscible oil, or emulsible oil at manufacturers' recommendations. (Dormant oil spray should *always* be applied if DDT is to be used later.)	Scale (See Fig. 4.) Red Mite Red bug (See Fig. 8.)	Oil sometimes causes burning in the delayed dormant. For use of "superior" type oils, see page 23. For use of "dinitro" oils against *rosy aphis*, see page 23. For red bug use 4% oil, see page 8.
2 Pre-blossom (a) Delayed dormant When blossom buds show ½ inch green. (See back cover.)	†Liquid lime-sulfur.... 2 gals. Water to make.....100 gals.	Scab (See Fig. 5.)	If weather hastens the breaking of buds, this spray can follow rather closely the "green tip" oil spray.
(b) Pre-pink Immediately before petals show. (See back cover.) *(Listen to the radio broadcasts.)*	*Flotation type sulfur 12 lbs. *or* Microfine dry wettable sulfur ... 6 lbs. *or* †Liquid lime-sulfur.. 1½ gals. Water .....100 gals. (For *flea-weevil* control, see page 8.)	Scab Black rot (frog-eye) (See Fig. 6.)	On varieties where lime-sulfur may cause serious russeting, or leaf injury, the use of flotation, or microfine sulfur is advisable starting with the pre-pink spray.
(c) Pink After blossom stems separate and before bloom opens. (See back cover.) Finish spraying in bloom if necessary.	*Flotation type sulfur 12 lbs. *or* Microfine dry wettable sulfur .. 6 lbs. Water .....100 gals. (For need of insecticide see under Further Suggestions.)	Scab Black rot (frog-eye) Cedar rust (See Fig. 41)	If cankerworms are troublesome, add 3 lbs. of lead arsenate. For *cedar rust*, Fermate is added, see page 50. For *cutworms*, see page 51.
Spraying in early bloom is advisable if scab threat is serious. Do not apply lead arsenate at this time			
3 Calyx Cup When the last of the petals are falling.	*Flotation type sulfur 10 lbs. *or* Microfine dry wettable sulfur ... 5 lbs. Lead arsenate ..... 3 lbs. Water .....100 gals.	Scab Codling moth Curculio (See Fig. 15) Cankerworm Black rot (frog-eye)	If *red bugs* are present, see page 8.

* Magnetic 70 sulfur paste is included in this group and because of its higher sulfur content should be used at two-thirds of the poundage recommended for flotation sulfur.

† For convenience, dry lime-sulfur, 8 lbs. in 2 (a); or 6 lbs. in 2 (b) can be substituted for the liquid lime-sulfur.

FOR THE CONTINUATION OF SCHEDULES SEE:

Page 5 For southern Ohio orchards troubled with blotch, Brooks spot, or bitter rot.

Page 6 For southern Ohio orchards where scab is the only apple disease to be combated.

Page 6 For northern Ohio orchards.

Page 7 For all orchards having a serious codling moth problem.

Refer to page 8 for emergency sprays.

SUMMER APPLE SPRAY PROGRAM

For Orchards not Seriously Infested by Codling Moth

For SOUTHERN Ohio where Bitter Rot, Brooks Spot or Blotch must be controlled.

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
4 **(a) First Cover** Ten days *after* petal-fall. (See Fig. 2.) (Watch Spray Service recommendations)	*Flotation type sulfur 8 lbs. *or* Microfine dry wettable sulfur..... 5 lbs. Lead arsenate..... 3 lbs. Water .....100 gals. or †Fermate ..... 2 lbs. Lead arsenate..... 3 lbs. Water .....100 gals.	Scab. (See Fig. 5) Codling moth Curculio (See Fig. 15) Black rot (frog-eye) (See Fig. 6) Blotch (See Fig. 28)	This spray is very important where scab has *not* been controlled in the pre-bloom period, *or* if overwintering scab *spores* are *still being discharged.* Do *not* delay this application where curculio is a problem. Use *Fermate if blotch* is a problem.
(b) Second Cover Three weeks after petal-fall. (See Fig. 3.) (Watch Spray Service recommendations)	†Fermate ..... 2 lbs. Lead arsenate..... 3 lbs. Water .....100 gals.	Codling moth Curculio Scab Blotch Black rot (frog-eye) Brooks spot	Flotation sulfur 8 lbs., or microfine sulfur 5 lbs. per 100 gals. water may be substituted for Fermate *if* Brooks spot or blotch is *not* a factor. Codling moth eggs will be hatching soon.
(c) Third Cover Two weeks after Second Cover. (Watch Spray Service recommendations)	Same as Second Cover. (See suggestions) (*Omit lead arsenate* on *early varieties.*)	Codling moth Scab (See See Fig. 51) Brooks spot Bitter rot (See Fig. 27) Black rot (frog-eye) Blotch	This spray is very important for codling moth, Brooks spot and blotch—on early varieties for bitter rot. In orchards where Brooks spot, blotch, or bitter rot do *not* occur flotation, or microfine sulfur as given under 4(b) under "further suggestions" can be used.
(d) Fourth Cover 2½ weeks after Third Cover. (Watch Spray Service recommendations)	Same as Second Cover.	Codling moth Scab Bitter rot Brooks spot Blotch Sooty fungus (See Fig. 11) Black rot (frog-eye)	In worm-free orchards, where bitter rot and Brooks spot are *not* a factor this spray may be omitted.
5 **Second Brood or Fifth Cover** Ten weeks after petal-fall, or 3 weeks after Fourth Cover. (Watch Spray Service recommendations)	†Fermate ..... 2 lbs. **Lead arsenate**..... 3 lbs Water .....100 gals. *or* †Fermate ..... 2 lbs. DDT (50% pwd.)... 1½ lbs. Water .....100 gals. (See further suggestions)	Codling moth Scab Bitter rot Blotch Brooks spot Sooty fungus Black rot (frog-eye)	*Avoid* spraying when temperatures are abnormally high, or spray injury may follow. In orchards where bitter rot and blotch do *not* occur flotation sulfur 8 lbs., or microfine sulfur 5 lbs. per 100 gals. water may be substituted for Fermate. Use DDT (50% pwd.) 1½ lbs. instead of lead arsenate *if leafhoppers threaten. If codling moth* is serious, follow suggestions under 6.
6 **Additional Sprays** About 2 weeks *after* No. 5. (See further suggestions)	†Fermate ..... 2 lbs. DDT (50% pwd.)... 1½ lbs. Water .....100 gals.	Bitter rot Codling moth Sooty fungus	Advised where bitter rot is a problem and where codling moth requires another spray. If conditions are favorable for the development of bitter rot a Fermate spray alone is suggested *again* in 2 weeks.

* Magnetic 70 sulfur paste is included in this group and because of its higher sulfur content should be used at two-thirds of the poundage recommended for flotation sulfur.

† Bordeaux mixture has been recommended in the past for control of blotch, Brooks spot and bitter rot. Fermate is now recommended in its place because of the severe injury which accompanies the use of copper compounds. Growers who still plan on using bordeaux should use a 2-4-100 formula in the First and Second Cover Sprays for *blotch* and *Brooks spot*; and 4-6-100 in subsequent sprays for *bitter rot* control.

Refer to page 8 for emergency sprays.

(See "boxed" note bottom of page 6.)

SUMMER APPLE SPRAY PROGRAM

For Orchards not Seriously Infested by Codling Moth

For NORTHERN Ohio, or OTHER AREAS where Blotch, Brooks Spot or Bitter Rot is *not* a factor.

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
(a) **First Cover** Ten days *after* petal-fall. (See Fig. 2.) (Watch Spray Service Recommendations)	*Flotation type sulfur 8 lbs. *or* Microfine dry wettable sulfur..... 5 lbs. Lead arsenate ..... 3 lbs. Water .....100 gals. (See Suggestions)	Codling moth Scab (See Fig. 5) Curculio (See Fig. 15) Black rot (frog-eye) (See Fig. 6.)	This spray is important where scab has *not* been controlled earlier, or when overwintering scab *spores* are *still* being discharged. Do *not* delay this application where curculio is a problem.
(b) **Second Cover** Three weeks after petal-fall. (See Fig. 3.) (Watch Spray Service Recommendations)	*Flotation type sulfur 8 lbs. *or* Microfine dry wettable sulfur..... 5 lbs. Lead arsenate ..... 3 lbs. Water .....100 gals.	Codling moth Curculio Scab Black rot (frog-eye)	This spray is timed to be just in advance of the first codling moth egg hatching.
(c) **Third Cover** Two weeks after Second Cover. (Watch Spray Serv. ice Recommendations)	Same as Second Cover (*Omit lead arsenate* on *early varieties*).	Codling moth Apple maggot (See Fig. 10) Scab Fig. 51 Black rot (frog-eye)	This spray is very important for codling moth. Where *apple maggot* is a problem, watch for Special Spray Letter.
(d) **Fourth Cover** 2½ weeks after Third Cover. (Watch Spray Service Recommendations)	Same as Second Cover	Codling moth Apple maggot Scab Sooty fungus (See Fig. 11) Black rot (frog-eye)	Very important for *apple maggot* control. Some worm-free orchards will *not* require this spray.
Second Brood or Fifth Cover Ten weeks after petal-fall, or 3 weeks after Fourth Cover. (Watch Spray Service Recommendations)	*Flotation type sulfur 8 lbs. *or* Microfine dry wettable sulfur..... 5 lbs. Lead arsenate ..... 3 lbs. Water .....100 gals. *or* *Flotation type sulfur 8 lbs. *or* Microfine dry wettable sulfur..... 5 lbs. DDT (50% pwd.)... 1½ lbs. Water .....100 gals.	Codling moth Apple maggot Sooty fungus Scab Black rot (frog-eye)	*Avoid* spraying if possible when temperatures are abnormally high or spray injury may result. Use DDT (50% pwd.) 1½ lbs. *instead* of lead arsenate *if leafhoppers* threaten. *If codling moth* is serious at this period follow suggestions under "emergency sprays," page 8.

* Magnetic 70 sulfur paste is included in this group and because of its higher sulfur content should be used at two-thirds of the poundage recommended for flotation sulfur.

NOTE: If there are locations in an apple orchard where there is poor aeration and sooty fungus is not controlled, another cover spray using sulfur as recommended in the second cover, but *omitting* lead arsenate would be advisable. This should be applied three weeks after the fifth cover. This extra sulfur spray would also aid in preventing late, or storage scab development.

Refer to page 8 for emergency sprays.

Primary apple scab infection may continue during rainy periods up to or beyond the First Cover Spray. Failure to protect the foliage and fruit with fungicide during this time may prove costly.

SUMMER APPLE SPRAY PROGRAM

For Orchards Seriously Infested by Codling Moth, or where the grower desires to use DDT in early cover sprays

Due to the very successful use of DDT against codling moth, this material is being recommended as the insecticide in all orchards where codling moth is a serious problem. Since different fungicides are recommended in different parts of the state, two schedules are advised—one for *northern*, and one for *southern* Ohio.

For northern Ohio orchards and other areas seriously infested by Codling Moth, and where Scab is the only apple disease to be combated.

Materials to use	First brood					Second brood
	First cover: 8 to 10 days after petal-fall spray (See Fig. 2)	Second† cover	Third cover	Fourth cover	Fifth† cover	Sixth cover
	Spaced at two week intervals.					
	These amounts needed in each 100 gallons of water:					
Lead arsenate	3 lbs.	3 lbs.	..	..	3 lbs.	..
Flotation type sulfur	8 lbs.	8 lbs.	8 lbs.	..	8 lbs.	8 lbs.
or						
Microfine dry wettable sulfur	5 lbs.	5 lbs.	5 lbs.	..	5 lbs.	5 lbs.
DDT (50% pwd.)	..	1½ lbs.	1½ lbs.	1½ lbs.	..	1½ lbs.

For Southern Ohio Orchards seriously infested by Codling Moth, and also troubled with Blotch, Bitter rot or Brooks spot

Materials to use	First brood					Second brood	
	First cover: 8 to 10 days after petal-fall (See Fig. 2)	Second† cover	Third cover	Fourth cover	Fifth† cover	Sixth cover	Seventh cover
	Spaced at two-week intervals.						
	These amounts needed in each 100 gallons of water:						
Lead arsenate	3 lbs.	3 lbs.	..	..	3 lbs.	..	..
Fermate*	2 lbs.	2 lbs.	2 lbs.	..	2 lbs.	2 lbs.	..
DDT (50% pwd.)	..	1½ lbs.	1½ lbs.	1½ lbs.	..	1½ lbs.	1½ lbs.

* DDT may be used with other fungicides recommended. It should *not* be used with lime-sulfur.

† Lead arsenate is included in the Second and Fifth Cover Sprays to combat red banded leaf-roller, since a schedule of DDT promotes leaf-roller.

Refer to page 4 for use of Magnetic 70 paste.

FURTHER SUGGESTIONS FOR DDT SCHEDULES

1. All trees to be sprayed with DDT should receive an oil spray in the dormant, or green tip stage.
2. If temperatures are above normal after the petal-fall the first cover spray should be applied in 8 days instead of 10, and if the temperatures continue high the first DDT spray (second cover) should follow in 8 days. After this, 2 weeks between sprays should be allowed.
3. If the calyx cup spray came late and the season is cool, the fifth cover spray may be omitted. In that case, lead arsenate should be included in the fourth cover spray.
4. If red mites start to appear in July, or early August, see page 8 and 31.

SPECIAL, OR EMERGENCY SPRAYS FOR APPLE

While these sprays have value against the pest, or for the purpose listed, growers should bear in mind that some of them are still in the experimental stage and may not be entirely satisfactory under all conditions.

WHAT FOR	MATERIALS TO USE	REMARKS
Apple Flea-weevil (See Fig. 7) Pre-pink, or pink spray.	Wettable, *or* flotation type sulfur. (See page 26) Cryolite ..... 5 lbs. Goulac ..... 3 oz. Water .....100 gals. Blood albumin can be used in place of goulac, if available.	Apply very thoroughly covering the expanding foliage as soon as first feeding is observed. If the presence of the insects is *not* discovered until trees open into bloom and codling moth is *not* serious, apply the Cryolite combination with sulfur and spreader in the calyx cup spray, instead of lead arsenate. Spraying to cover the undersurface of leaves is necessary. Do *not* use lime sulfur.
Rose Chafer (May or June) (Also recommended for rose chafer on peaches & grapes)	DDT (50% pwd.)... 2 lbs. *or* Chlordane (40% pwd.)..... 2 lbs. Water .....100 gals.	Spray as soon as beetles appear. Attacks usually occur on or near sandy spots where the larvae develop. Fungicide may be included if necessary. For *rose chafer* on grapes, see schedule on page 20.
Grasshoppers	Chlordane (40% pwd.)..... 2½ lbs. Water .....100 gals.	Apply to the *grass cover* in the orchard. Will *not* injure tree foliage or fruits. Apply just as soon as need arises.
Apple Red Bug (Present only in northeastern Ohio; not abundant in 1947 or 1948).	Oil, 4% applied when tree is *dormant* *or* Nicotine sulfate, 1 pint per 100 gals. in the calyx cup spray *or* DDT (2 lbs. 50% pwd.) added in the calyx cup spray.	Kills the over-wintering eggs located in the bark. Since this is a contact spray for red bug, great care is necessary to cover the growth in the center of the tree. The application should be made from the ground under the tree as well as from without, and is most effective if applied on a warm day. In orchards where the DDT schedule is followed no red bug problem arises.
European Red Mite (July or Aug.)	No ideal summer spray is available. Four materials are suggested for emergency use. *Two* applications are usually needed. (See Page 31). 1. Dinitro ..... 6 oz. (Dry Mix No. 1) Water .....100 gals. *or* 2. Dinitro (DN-111) 1¼ lbs. Water .....100 gals. *or* 3. Di-Methyl carbinol (Dimite) ..... 1 pt. Water .....100 gals. *or* 4. Hexaethyl tetra-phosphate ..... ½ pt. Water .....100 gals. *Experimental use only*: 5. Parathion 25%... 5 oz. Water .....100 gals. *or* 6. Tetraethyl pyro-phosphate..... 4 oz. Water .....100 gals.	Apply only in case mites threaten. To be effective they must be applied promptly and *before* serious damage occurs. Very thorough coverage of the under-surfaces of the leaves is necessary. Do *not* use dinitro with or following summer oil, or with materials containing lime. They can be combined with lead arsenate, DDT, mild sulfurs, and Fermate. Dry Mix No. 1 is effective and only slightly more dangerous to foliage and fruit than DN-111. It is much less expensive. *Observe all cautions as to temperatures and spray combinations when using dinitros.* HETP, which is the abbrevation for No. 4, is expensive and irritating to the skin which must be protected. It also damages some types of spray cylinder linings. In Ohio it is sold under the trade names of: Vapotone, Hexcide & Killex 100. Follow manufacturers' directions carefully. Due to the extreme toxicity of parathion (No. 5) and TEPP (No. 6) to warm blooded animals, they should be handled with great care. Use masks, avoid contact with skin and keep out of spray drift.
Red Banded Leaf-roller (See Fig. 12) (If heavy infestation is present in July or Aug.)	Parathion 25% .... 1 lb. Water .....100 gals. *or* "Rothane" DDD (50%) ..... 2 lbs. Water .....100 gals.	See *Cautions under European Red Mite* before using parathion. A complete summer spray schedule of lead arsenate; or lead arsenate included in the Second and Fifth cover sprays of the DDT schedule should prevent a serious leaf-roller problem.
Apple Leafhoppers	DDT (50% pwd.)... 1½ lbs. Water .....100 gals.	Nymphs usually appear in July or August. Best insurance against damage from leafhoppers is the inclusion of DDT in the *second brood* codling moth spray. Be sure to cover foliage on the *inside* of the tree.
Codling Moth (August)	DDT (50% pwd.)... 1½ lbs. Water .....100 gals.	This spray is advised for use during August where worm entrances indicate an emergency spray to be necessary. Do *not* apply within 2 weeks of harvest.
Harvest Sprays	Commercial preparations on the market. Follow manufacturers' recommendations.	Apply at first sign of natural dropping of the fruit. Harvest sprays have been effective on summer and fall varieties of apples, and on Stayman Winesap. See page 17.

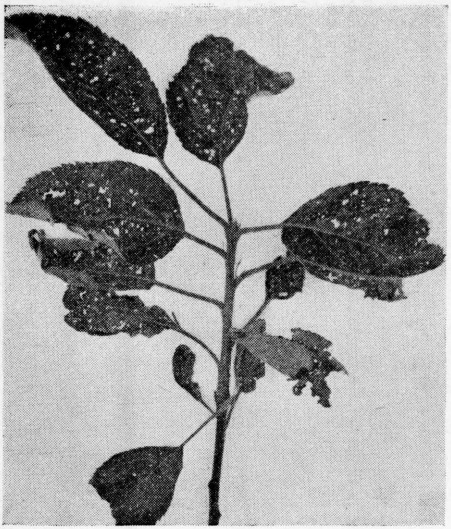


Fig. 7.—Apple flea-weevil injury to foliage.

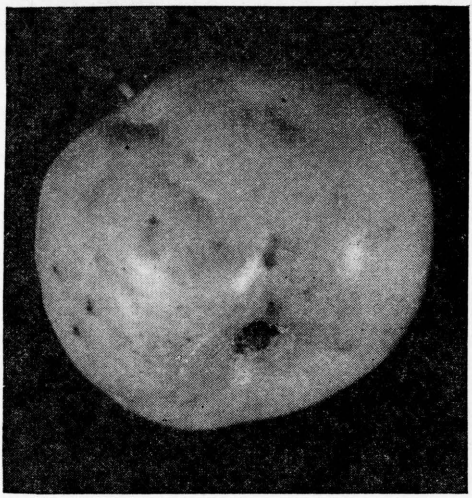


Fig. 8.—Fruit deformed by feeding punctures of the apple red bug.

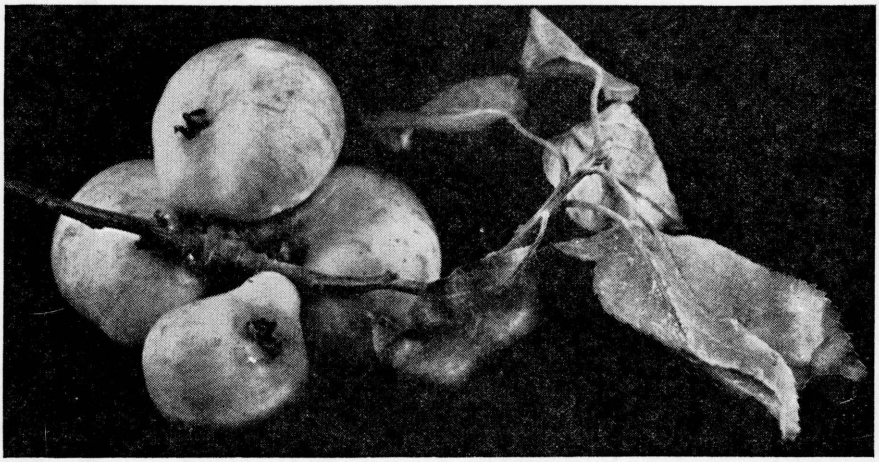


Fig. 9.—Apples stunted by feeding of rosy aphis.

Varietal Susceptibility to Diseases and to Spray Injury

The various varieties of apples show marked differences in degree of susceptibility and resistance to disease and spray russeting.

In the following table is listed the susceptibility of different varieties to diseases and to spray injury. By observing these responses, one can adjust the spray recommendations to better fit the orchard.

Apple scab and fire blight attack vigorously growing trees more frequently and severely than trees of low vitality. The opposite is true of black rot and apple measles. Trees making poor growth are likely to be injured by sprays which do not harm vigorously growing trees of the same variety. The margin of safety for effective sprays is narrow, and constant search is being made for safer and better materials. Caustic sprays have been eliminated as much as possible.

Degree of Susceptibility of Ohio Apple Varieties to Diseases and to Spray Injury

Variety	Scab	Bitter Rot	Blotch	Brooks Spot	Fire Blight	Cedar Rust	Spray Injury
Baldwin	Moderate	Moderate	Slight	Slight	Slight	Slight	Very
Ben Davis	Very	Very	Moderate	Slight	Slight	Slight	Very
Cortland	Very	Very	Very	Slight	Very	Moderate	Slight
Delicious*	Very	Moderate	Slight	Moderate	Slight	Moderate	Slight
Duchess	Moderate	Slight	Very	Slight	Slight	Slight	Slight
Golden Delicious	Slight	Very	Moderate	Very	Slight	Slight	Very
Grimes	Slight	Very	Slight	Very	Very	Slight	Very
Jonathan	Slight	Very	Slight	Very	Very	Moderate	Very
McIntosh	Very	Very	Very	Slight	Slight	Slight	Slight
N. Spy	Very	Moderate	Slight	Slight	Slight	Slight	Slight
R. I. Greening	Moderate	Very	Slight	Slight	Very	Slight	Moderate
Rome	Very	Moderate	Moderate	Moderate	Moderate	Very	Slight
Stayman	Moderate	Moderate	Slight	Moderate	Slight	Slight	Moderate
Turley	Moderate	Moderate	Slight	Moderate	Slight	Slight	Moderate
Wealthy	Moderate	Slight	Slight	Slight	Very	Moderate	Slight
Winter Banana	Very	Very	Slight	Slight	Slight	Moderate	Moderate
Yellow Transparent	Moderate	Slight	Slight	Slight	Very	Slight	Slight

* Varieties like Delicious, Rome, Stayman, etc., include the red sports of those varieties.

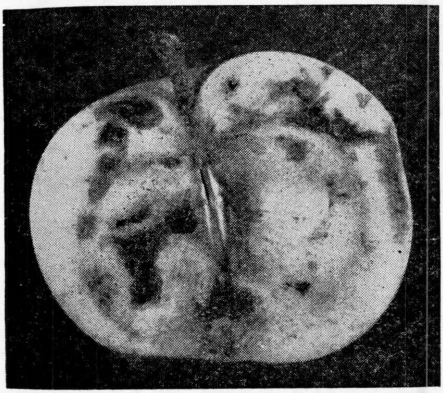


Fig. 10.—Injury caused by apple maggot, or "railroad worm."

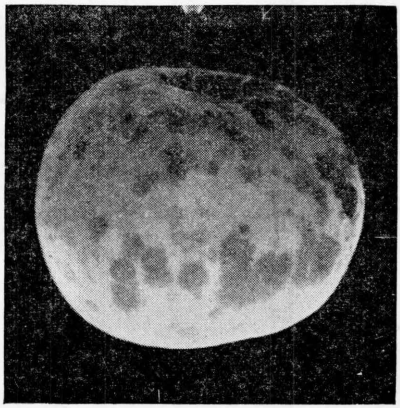


Fig. 11.—Sooty fungus.

INSECT BLEMISHES THROWING APPLES OUT OF GRADE

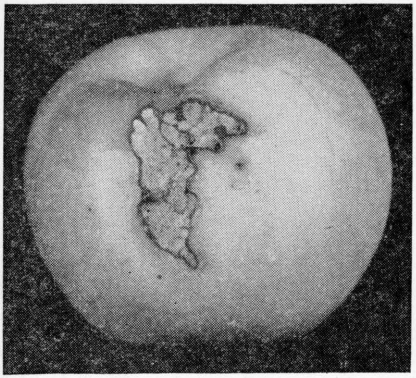


Fig. 12.—Injury caused by red banded leaf-roller.

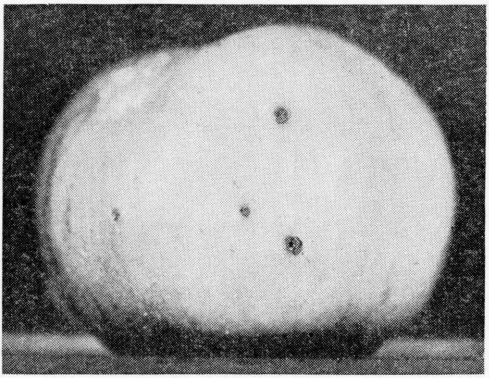


Fig. 13.—Codling moth larvae "stings" on an apple kept covered with lead arsenate.

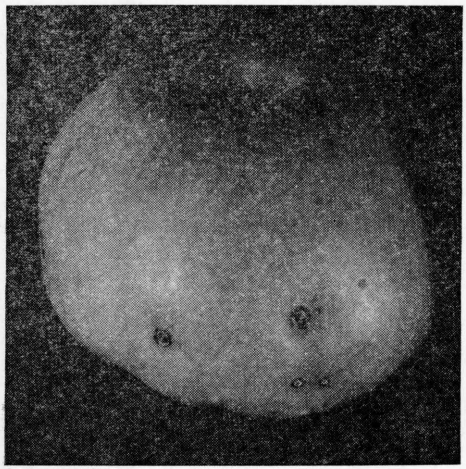


Fig. 14.—Feeding punctures of apple curculio.

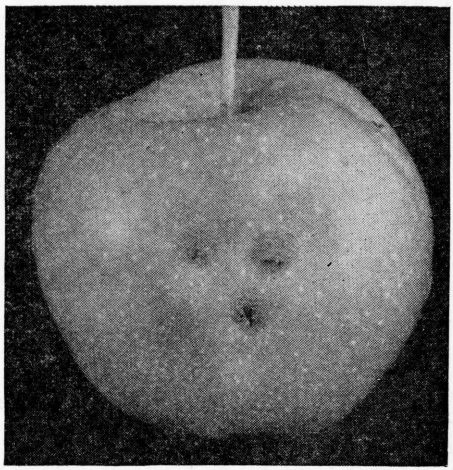


Fig. 15.—Egg-laying scars in apple caused by plum curculio.

PEACH SPRAY PROGRAM

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
Dormant In early spring *before* buds swell.	Dormant oil (3%) *with* 4-6-100 bordeaux mixture	Leaf curl (See Fig. 18) Scale Red mite	Apply every year. This spray *must not* be omitted if DDT is to be used in the summer spray program.
Bloom Early to full bloom.	*Microfine dry wettable sulfur ..... 6 lbs. DDT (50% pwd.) .... 2 lbs. Water .....100 gals.	Brown rot (Blossom blight) Plant bug (See Fig. 45)	This spray is important where the blossom blight stage of brown rot has been serious. Important where tarnished plant bugs have been a problem. Use only sulfur spray *if* plant bugs have *not* been a problem.
Shuck-Split When shucks begin to split.	*Microfine dry wettable sulfur ..... 5 lbs. Benzene hexachloride.. 3 lbs. Water .....100 gals.	Brown rot Curculio	This rate of benzene hexachloride is based on the 6% gamma isomer. (See page 29.)
First Cover Ten days *after* the shuck-split spray.	*Microfine dry wettable sulfur ..... 5 lbs. Benzene hexachloride.. 3 lbs. Water .....100 gals.	Scab (See Fig. 19) Brown rot Curculio	If *rose chafer* appears use chlordane as given on page 8 instead of BHC in this spray. If curculio has been serious follow with a chlordane spray of 2½ lbs. (40% pwd.) in 10 days.
Second Cover Five weeks after First Cover.	*Microfine dry wettable sulfur ..... 5 lbs. DDT (50% pwd.) .... 2 lbs. Water .....100 gals.	Brown rot Oriental moth (See Fig. 16)	This is the first application for Oriental fruit moth to all varieties and the only one on Golden Jubilee and others of the same maturity.
Third Cover Two weeks after Second Cover. (See †)	Same as Second Cover.	Brown rot Oriental moth	*Omit* on *Haven* and earlier maturing varieties. (See under Fourth Cover). If mites have been serious include 1¼ lbs. of DN-111 per 100 gallons spray as a preventive.
Fourth Cover Three or four weeks *before* harvest. (See Further Suggestions).	*Microfine dry wettable sulfur ..... 6 lbs. DDT (50% pwd.) ....1½ lbs. Water .....100 gals.	Brown rot Oriental moth (See Fig. 17)	*Three* weeks before harvest for *Haven* varieties. *Four* weeks before harvest for *Elberta* maturing varieties. If *mites* have been serious include 1¼ lbs. of DN-111 per 100 gallons spray as a preventive.
Pre-harvest *Five to seven* days *before* harvest.	*Microfine dry wettable sulfur ..... 6 lbs. Water .....100 gals.	Brown rot (See Fig. 40)	A 90-10 sulfur-lime *dust* can be used here instead of a spray.

* Flotation type sulfur paste, or Magnetic 70 paste may be substituted if desired. In such case flotation type sulfur should be used at 10 lbs. in the *bloom spray* and *pre-harvest spray*; and at 8 lbs. elsewhere. Magnetic 70 paste should be used at 6 lbs. throughout.

† The *Third Cover Spray* may be omitted *if* Oriental fruit moth has *not* been serious. *Dusting* with DDT for Oriental fruit moth control, even where extra applications are made, is less effective than spraying.

For *peach tree borer* control, see pages 54-56. Keep bearing orchards cleanly mowed.

For control of *peach canker*, see page 48.

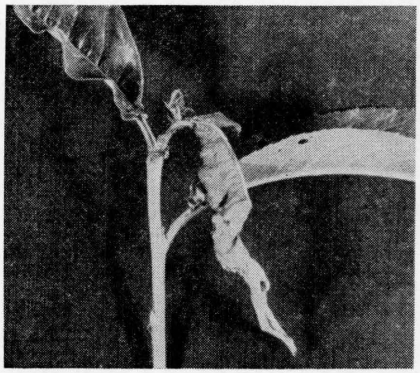


Fig. 16.—Peach twig injured by Oriental fruit moth.

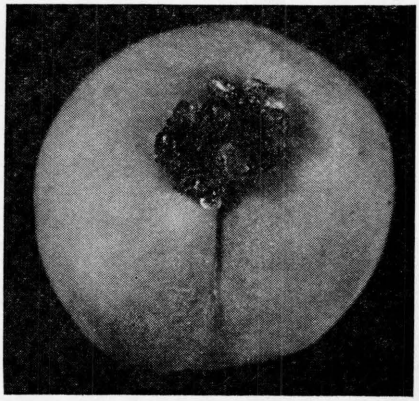


Fig. 17.—Peach damaged by Oriental fruit moth larva.

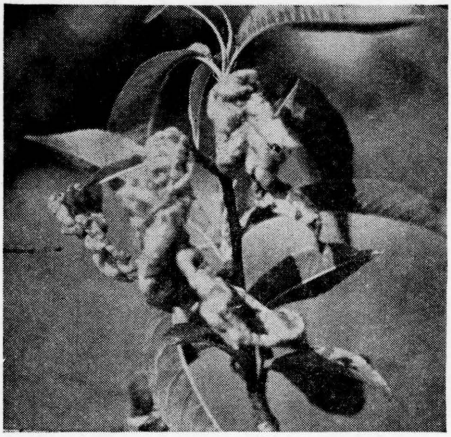


Fig. 18.—Peach leaf curl.

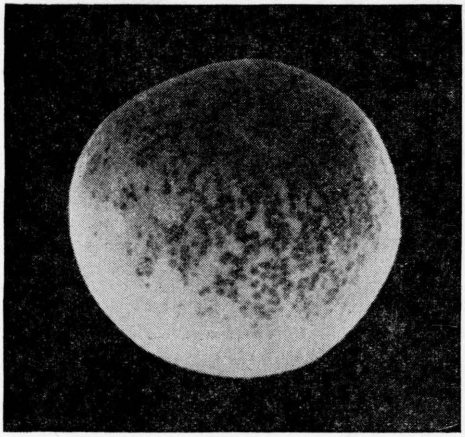


Fig. 19.—Peach scab.

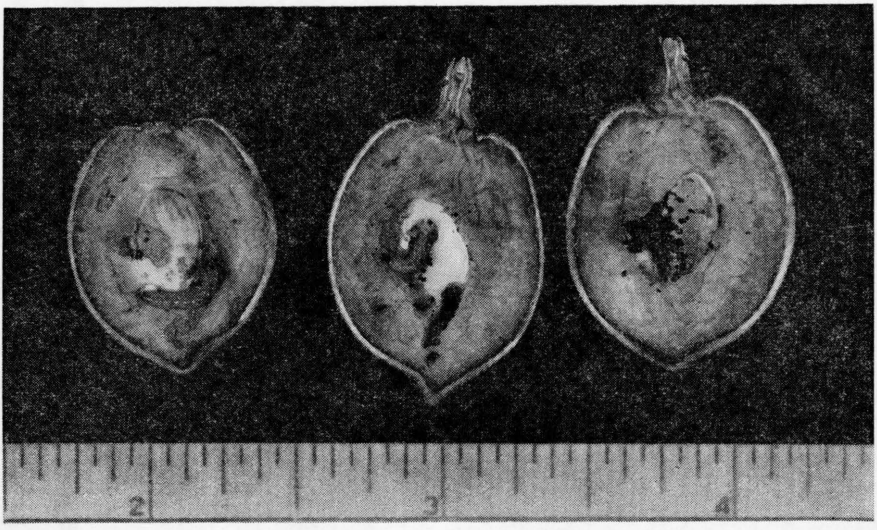


Fig. 20.—Oriental fruit moth larvae in peach.

SWEET CHERRY SPRAY PROGRAM

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
Dormant Before buds open.	Dinitro compound at manufacturers' recommendations. (Combine with 3% dormant oil if scale or red mite is also present). (Use only in full dormant period).	Black cherry aphis	Two gals. of liquid lime-sulfur plus 1 pt. of nicotine sulfate to 100 gals. of spray can be applied in delayed dormant to control aphis. To control red mite and scale alone, see under plum spray program, page 16.
Shuck-Fall When the shucks are splitting and falling from the expanding fruits.	*Fixed copper (based on 50% metallic copper) .... 1 lb. †Flotation type sulfur 5 lbs. *or* Microfine dry wettable sulfur ..... 4 lbs. Hydrated lime ..... 3 lbs. Lead arsenate..... 3 lbs. Water .....100 gals.	Leaf spot (See Fig. 21) Brown rot Curculio Slug	In some seasons an earlier application may be advisable for leaf spot. Watch Spray Service Recommendations.
First Cover Two weeks after shuck-fall.	Same as shuck-fall, except omit lead arsenate.	Leaf spot Brown rot	Should aphis appear at this time no spray is likely to be effective.
Second Cover, or Pre-harvest When fruits are beginning to color.	†Flotation type sulfur 8 lbs. *or* Microfine dry wettable sulfur ..... 6 lbs. Water .....100 gals.	Leaf spot Brown rot	An additional sulfur spray, or sulfur dust without lead may be needed if brown rot weather occurs.
After Harvest Immediately after fruit is picked.	*Fixed copper (based on 50% metallic copper) ....1½ lbs. Hydrated lime ..... 3 lbs. Water .....100 gals.	Leaf spot	Important spray to maintain foliage and tree vigor. If slugs are present, include 2 lbs. of lead arsenate.

* A discussion of fixed copper compounds is given on page 28.
† Magnetic 70 sulfur paste is included in this group and because of its higher sulfur content should be used at two-thirds of the poundage recommended for flotation sulfur.

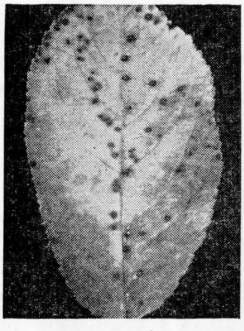


Fig. 21.—Cherry leaf spot.

Fig. 22.—Control of cherry leaf spot; excellent on left, sprayed with fixed copper; poor, on right, sprayed with lime-sulfur.

SOUR CHERRY SPRAY PROGRAM

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
Shuck-Fall When the shucks are splitting and falling from the expanding fruits.	*Fixed copper (based on 50% metallic) .....1½ lbs. Hydrated lime..... 3 lbs. Lead arsenate..... 3 lbs. Water ..... 100 gals. *or* 1-2-100 bordeaux mixture Lead arsenate..... 3 lbs.	Leaf spot (See Fig. 21) Brown rot Curculio Slug	In some seasons an earlier application may be advisable for leaf spot. Watch Spray Service Recommendations. Omit the extra lime if bordeaux is used.
First Cover Two to three weeks after the shuck-fall spray.	Same as shuck-fall, except omit lead arsenate.	Leaf spot Brown rot	This is a very important leaf spot spray.
Second Cover or Pre-Harvest When fruits are beginning to color.	Same as shuck-fall, except omit lead arsenate.	Leaf spot Brown rot	This is a very important disease spray. If cherry maggot is a problem, include 2½ lbs. of lead arsenate and apply to all sour varieties when "Early Richmond" first shows red, then wash fruit to remove residue.
After Harvert Immediately after fruit is picked.	Same as shuck-fall, except omit lead arsenate, unless slugs are present. (See note under Further Suggestions.)	Leaf spot	This spray is important to protect the foliage. Cover leaves thoroughly. Trees which drop their leaves in midsummer develop weak blossom buds. If slugs are present, include 2 lbs. of lead arsenate.

* A discussion of fixed copper compounds is given on page 28.
(For cherry yellows, see page 48.)

PEAR SPRAY PROGRAM

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
Dormant *Before* buds open, or when beginning to swell.	Oil emulsion carrying 3% oil *or* Miscible oil at manufacturers' recommendations.	Scale Pear psylla Blister mite Red mite	This spray is necessary only in case one or more of these insects is serious. The addition of dinitro in the *green tip* stage is effective against psylla.
Cluster Bud When blossom buds are separated in the cluster *before* bloom.	*Flotation type sulfur. 12 lbs. *or* Microfine dry wettable sulfur .... 6 lbs. Water .....100 gals.	Scab Leaf spot	This spray may be omitted if disease is *not* prevalent.
Calyx Cup When the last of the petals are falling.	Same as Cluster Bud Spray *plus* Lead arsenate ..... 3 lbs.	Codling moth Scab Leaf spot Curculio	Spray blossom clusters thoroughly.
First Cover Three to 4 weeks *after* petal-fall.	Same as Cluster Bud Spray *plus* Lead arsenate ..... 3 lbs.	Codling moth Curculio Scab Pear slug	Cover little fruits and foliage thoroughly.
Second Cover Two weeks *after* First Cover.	Lead arsenate ..... 3 lbs. Water .....100 gals.	Codling moth Slugs	Can be omitted where codling moth is *not* serious.
Third Cover Nine to 10 weeks *after* petal-fall.	Same as Second Cover (See Suggestion at right.)	Codling moth	Avoid spraying if possible when temperature is abnormally high.

* Magnetic 70 sulfur paste is included in this group and because of its higher sulfur content should be used at two-thirds the poundage recommended for flotation sulfur.

PLUM SPRAY PROGRAM

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
Dormant When the tips of the buds show green but *before* leaf tips are visible.	Oil emulsion carrying 3% oil *or* Miscible oil at manufacturers' recommendations.	Red mite Scale	For black knot, see page 50.
Shuck-fall When shucks are splitting and falling.	*Fixed copper (based on 50% metallic).. 1½ lbs. Lead arsenate..... 2½ lbs. Hydrated lime..... 3 lbs. Water .....100 gals. *or* **Chlordane (40% pwd.) ..... 2½ lbs. Fermate ..... 1½ lbs. Water .....100 gals.	Curculio Leaf spot Brown rot (See Fig. 40)	Chlordane is suggested where lead arsenate has failed to give satisfactory control of curculio.
First Cover Ten days *after* shuck-fall.	Same as Shuck-fall.	Curculio Leaf spot Brown rot	Follow either lead arsenate, or chlordane schedule as above.
Second Cover Ten days *after* First Cover.	*Fixed copper (based on 50% metallic).. 1½ lbs. Hydrated lime..... 3 lbs. Water .....100 gals. *or* **Chlordane (40% pwd.) ..... 2½ lbs. Fermate ..... 1½ lbs. Water .....100 gals.	Leaf spot Brown rot Curculio	The chlordane-Fermate spray is recommended here in orchards where curculio has been very persistent.
Third Cover Two weeks *after* Second Cover.	†Microfine dry wettable sulfur..... 6 lbs. Water .....100 gals.	Brown rot Leaf spot	
Fourth Cover Three weeks *before* harvest.	Same as Third Cover.	Brown rot	
Pre-harvest Seven to 10 days before harvest.	Same as Third Cover.	Brown rot	This is a dangerous period for *brown rot* infection. Additional sprays, or 90-10 sulfur-lime dusts should be applied whenever wet weather prevails.

* See page 28, fixed coppers. Hydrated lime, 3 lbs., needed when fixed copper is used.
** *Do not use* hydrated lime with chlordane-Fermate schedule.
† Flotation type sulfur paste, 10 lbs.; or Magnetic 70, 7 lbs., may be used as the fungicide.

PROGRAM FOR YOUNG FRUIT TREES NOT YET BEARING

Young fruit trees not yet in bearing should be carefully inspected annually in advance of the dormant spraying season. If *scale insects*, or *red mite eggs* are found, the trees should receive the dormant oil spray recommended for use on bearing trees of the same sort. Sour cherry trees rarely require a dormant spray.

Young peach trees should receive a dormant spray for *leaf curl* as given in the peach schedule (see page 12).

Young apple trees should receive at least one spray in the late pre-bloom period for *apple scab*. If scab is serious, a subsequent spray should be applied at the first cover period as given for bearing trees.

A watch should be maintained just previous to bloom for young *cankerworms*. If they are found, lead arsenate should be applied along with the sulfur fungicide recommended for the pink spray as for bearing trees (see page 4).

Because young cherry trees are as susceptible to *leaf spot* infection and *slug* attack as are bearing trees, the young cherry orchard should receive the sprays recommended for these two troubles in the program for bearing trees (see page 14-15).

Young peach trees should be examined in the fall and spring for *peach tree borers.* If found present, the borers should be removed by careful use of a knife, or the gas treatment given on pages 54 to 56 should be applied.

Tree hoppers sometimes seriously damage the trunks and branches of young trees by laying their eggs in the bark, particularly if alfalfa or sweet clover is used as a cover crop. If clean cultivation or frequent mowing of all ground cover is practiced until the end of June of each year, serious damage from tree hoppers will be avoided.

Grasshoppers seriously defoliate young trees in some seasons. Careful watch will detect the presence of these pests and an application of chlordane will put a stop to their work. The spray should be applied throughout the grass near and between the tree rows. For directions about making poisoned bait consult your county agent.

In years when the *periodical cicada* (17-year locust) is due, young trees, located near a woods or near old apple trees that have maintained a heavy brood of cicadas in years of previous visitations, should be protected by wrapping them with cheesecloth or muslin. The entire top, with all of the foliage and branches, should be enclosed during the period from May 25 to about July 10.

The next visitation of cicadas will come in Trumbull, Mahoning and Columbiana counties in 1951; in western Ohio in 1953; and 12 counties of southwestern Ohio, from Gallia to Clermont and Warren counties inclusive, in 1957.

Harvest Sprays

Several brands of the napthalene-acetic acid compounds used as harvest sprays have been very efficient in preventing pre-harvest drop of fruit on all summer and early fall apple varieties. Varieties ripening up to and including Wealthy have responded to its use.

The results from the use of these napthalene-acetic acid sprays on later varieties, beginning with McIntosh, have not been so well defined. Stayman Winesap has responded more favorably than most winter varieties. Fairly good results have been secured on Rome Beauty, Golden Delicious and Cortland. There is justification for the use of these pre-harvest sprays on at least the foregoing named varieties. The harvest season may be prolonged by 4 or 5 days. The material should be applied at the first sign of normal dropping. It begins to be effective within two or three days from the date of application. The cost per application including materials, labor and applcation ranges from 3 to 4 cents per bushel.

More recently the use of 2,4-D for preventing pre-mature drop of fruit, especially Stayman Winesap, has been suggested. The Experiment Station has used this material on Stayman Winesap for two seasons. At

a dilution of 10 parts per million 2,4-D applied 4 weeks before harvest reduced the drop of Stayman Winesap to a greater degree than the conventional napthalene-acetic acid spray.

The after effects from 2,4-D as a harvest spray makes its use for this purpose of doubtful value. Distorted foliage as well as abnormal blooming may occur the year following the use of 2,4-D as a pre-harvest spray. Because of the foregoing reason it is *not* recommended.

Facts About Spraying Grapes

It is impossible to formulate a spray schedule for grapes that will have general application. The insect and disease problems of vineyards

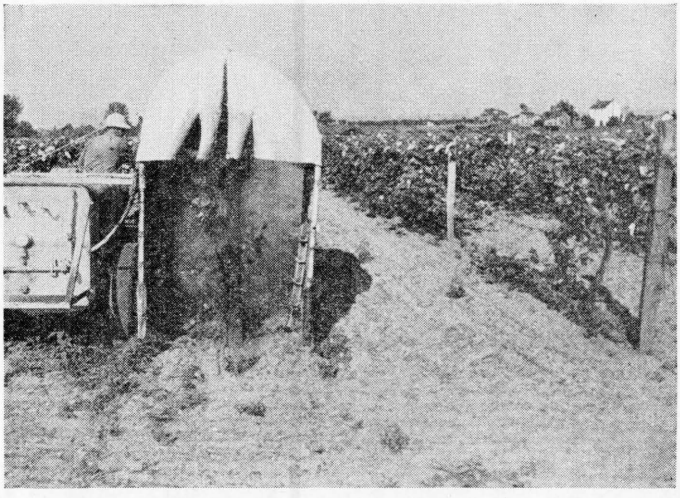


Fig. 23.—Spraying grapes with covered spray boom.

located in different communities, and even in vineyards of the same community, are frequently quite variable. For example, grape mildew, while serious on the Lake Erie islands and at the west of Lake Erie, is rarely a problem in the commercial grape belt east of Cleveland. Rose chafer usually is troublesome only in vineyards with sandy soil. Many grape insects are quite localized in their distribution.

In vineyards of recent plantings excellent grapes are sometimes grown without any sprays. In most mature vineyards at least three, and more often four spray applications are advisable. Only a few vineyards will require the full spray schedule recommended for those having a serious berry-moth or black rot problem.

Each grower should study his conditions and apply such sprays as are necessary. Thoroughness is very essential; the gallonage suggested under each spray is a good guide to follow. Grape pests cannot be

controlled, except by very thorough applications. The use of a canopy covered spray boom gives much better coverage with less waste of the spraying material than the open type of fixed boom (see Fig. 23).

Mature vineyards will require from 150 to 300 gallons of spray per acre per application, depending upon the size and density of foliage. Good pressure and careful adjustment of spray nozzles and boom are essential. Cultural control to bury the berry-moth cocoons should be practiced as suggested in the grape spray program. This makes it easier to control berry-moth.

The first *pre-bloom spray* when new shoots are *10"* to *12"* long is very important in the control of *black rot* and *dead arm*. Dead arm is a fungous disease, which kills or weakens one arm of a vine. The application of this early spray, plus cutting out all weak wood, will control it.

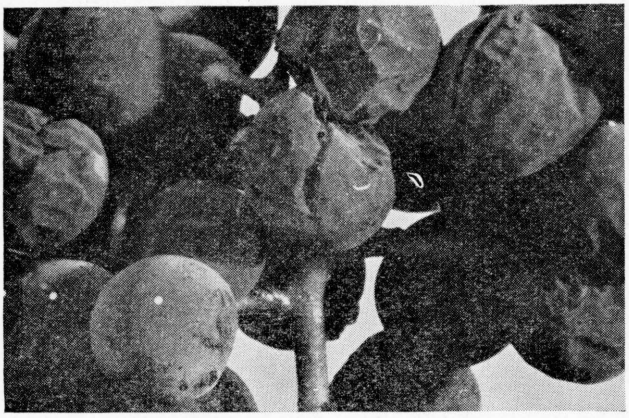


Fig. 24.—Grape berry-moth damage.

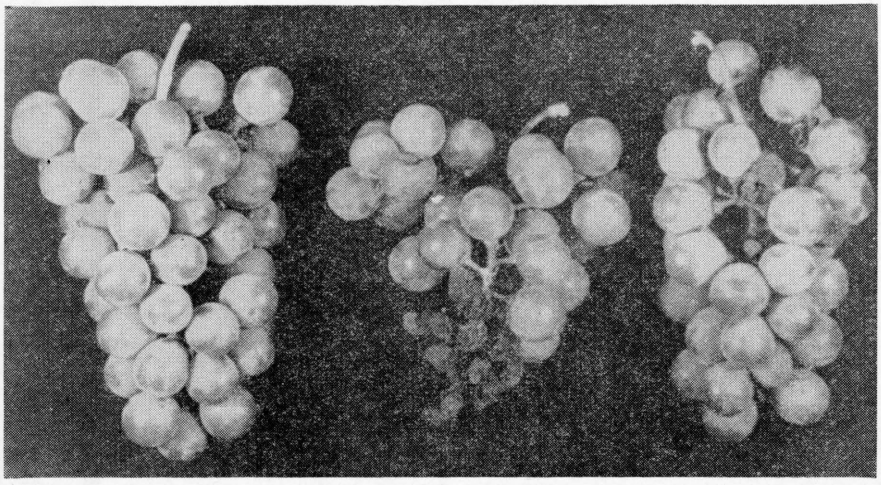


Fig. 25.—Black rot of grape.

GRAPE SPRAY PROGRAM

(For Commercial Vineyards having a serious Berry-moth or Black Rot Problem)
(See NOTE)

NAME AND TIME OF SPRAY	MATERIALS TO USE	TO CONTROL	FURTHER SUGGESTIONS
Delayed Dormant Shoots ½"-¾" long.	8-8-100 bordeaux mixture Summer spray oil ....2½ qts. *or* *Fermate ..... 2 lbs. Water .....100 gals.	Black rot (See Fig. 25)	Watch out for injury to buds by *climbing cutworms*, see page 51. To aid in the control of berry-moth worms, see cultural method below. Apply 150-200 gals. per acre.
1st Pre-bloom When shoots are 10"-12" long.	*Fermate ..... 2 lbs. Water .....100 gals. *or* 6-6-100 bordeaux mixture Summer spray oil ....2½ qts.	Black rot Dead arm	Very important for black rot. Apply 150-200 gals. per acre.
2nd Pre-bloom When very first bloom appears.	*Fermate ..... 2 lbs. DDT (50% pwd.) ....1½ lbs. Water .....100 gals. *or* 6-6-100 bordeaux mixture DDT (50% pwd.) ....1½ lbs. Summer spray oil ....2½ qts.	Black rot Mildew Berry-moth (See Fig. 24) Rose chafer	Very important for black rot and berry-moth in certain areas. Watch for *rose chafers*. If present use 2 lbs. of DDT (50% pwd.). If *mildew* is a problem use the bordeaux mixture schedule. Apply 200-250 gals. per acre.
Petal-fall Immediately *after* bloom.	*Fermate ..... 2 lbs. DDT (50% pwd.) ....1½ lbs. Water .....100 gals. *or* 4-4-100 bordeaux mixture DDT (50% pwd.) ....1½ lbs. Summer spray oil .... 2 qts. (For *leaf-roller* see under Further Suggestions).	Black rot Mildew Berry-moth Leafhoppers Root-worm	Berry-moth eggs begin hatching. If *mildew* is a problem use the bordeaux mixture schedule. If *red banded leaf-roller* is a problem 3 lbs. of lead arsenate should be included. Apply 200-250 gals. per acre.
1st Cover Spray 7-10 days *after* petal-fall.	DDT (50% pwd.) ....1½ lbs. Water .....100 gals.	Berry-moth Leafhopper Root-worm Mildew†	Important for leafhoppers. Apply 250-300 gals. per acre.
2nd Cover Spray First week of August. (See Suggestions)	Same as 1st Cover Spray.	Berry-moth Root-worm Mildew†	Time suggested should be a few days earlier near the *west* end of Lake Erie. Apply 250-300 gals. per acre.
3rd Cover Spray Mid-August, or 10 days *after* 2nd Cover spray.	Same as 1st Cover Spray.	Berry-moth Mildew†	Very important in some seasons especially where crop is light. Apply 250-300 gals. per acre.
4th Cover Spray 10 days *after* 3rd Cover Spray.	Same as 1st Cover Spray.	Berry-moth	Important in vineyards where late berry-moth is severe. Can be *omitted* in many vineyards. Apply 250-300 gals. per acre.

Culture for berry-moth control—If vineyard is ridged up under trellis before grape harvest in fall, hoe out ridge cleanly from under trellis early in spring and work row centers thoroughly covering all hoed-out trash and soil, completing operation not later than 15 days before bloom. *Do not* work centers again until 15 days after bloom.

If vineyard is level overwinter, throw soil toward vines covering thoroughly all trash under the grape trellis, completing the operation at least 15 days before bloom. Row centers may be worked early and as often as desired. *Do not* remove the soil ridge from under the trellis until 15 days after bloom.

If vineyard is ridged up after grape harvest in the fall, do not hoe out the ridge from under the trellis until 15 days after bloom. Row centers may be worked as desired.

* *Fermate* has controlled *black rot* better than bordeaux mixture and without foliage injury. It is preferred where mildew is *not* a problem.

† On varieties and in locations where *mildew* is prevalent, use 2-2-100 bordeaux; or fixed copper 1 lb. (based on 50% copper) plus 3 lbs. hydrated lime in all sprays beginning with the *first cover*.

NOTE: Most vineyards require this complete spray program as "insurance" against losses from insects and diseases in seasons favorable for these pests. During seasons unfavorable for diseases, or in vineyards where berry-moth is not a serious problem, fewer spray applications may suffice.

STRAWBERRY INSECT AND DISEASE CONTROL

Insect or Disease	Nature of Injury	Control
Strawberry leaf-roller	Leaflets folded and webbed together, with a small green larva feeding within.	Spray with 2 lbs. (50% wettable powder) DDT in 100 gallons at 15 day intervals beginning late in August to destroy hibernating larvae. If a spray is needed when berries are ripening, use 1 gal. summer oil and ⅔ pint Black leaf 40 in 100 gallons.
Root worms (Strawberry leaf beetle)	Small beetles eat numerous holes in the leaves. Larvae feed on the roots.	Plow down infested beds in July to kill the larvae. Rotate beds with new planting at some distance from old ones.
Crown borer	Crown of plants hollowed out by white legless grubs about 1/5 inch in length.	Same as for root worms.
Spittle bugs	White frothy masses ½ inch or more in diameter covering small green insects on stem and leaves.	Spray with 3 lbs. of benzene hexachloride (6% gamma isomer) per 100 gals. water.
White grubs	Large, fleshy, white grubs that attack the roots of new plants.	Avoid planting strawberries in newly plowed sod or in a field where grubs are abundant.
(1) Leaf spot (2) Scorch	1. Leaves show purplish spots, with gray center. 2. Irregular purplish spots; leaf margin has scorched appearance.	Grow resistant varieties such as Premier. When susceptible varieties are grown spray new plantings with 4-6-100 bordeaux mixture at 10-day intervals if the diseases become troublesome. Do not spray bearing plantings after the fruit becomes one-third grown.
Red stele	Plants wilt and die usually in May or just preceding or during harvest. Roots of plants decayed and showing red cores even while outside of roots are mostly undecayed. Roots are devoid of fibrous hairy laterals, giving a rat-tailed appearance.	Set only disease-free plants on well-drained fertile soil, uncontaminated by the red stele fungus. Since the fungus can live for several years in soil, practice crop rotation with four years intervening between strawberry crops.

RASPBERRY DISEASE AND INSECT CONTROL

Insect or Disease	Nature of Injury	Control
Virus Diseases (1) Mosaic (2) Leaf Curl (3) Streak	Foliage abnormalities such as mottling, curling, etc., stunted and crumbly berries. (See raspberry bulletin 454 for detailed symptoms.)	Use healthy planting stock. Isolate new plantings from other diseased brambles, cultivated and wild. "Rogue out" virus-diseased plants when they appear.
Orange Rust	Small distorted leaves with orange-colored spore-bodies on under-side. Spindly or willowy shoots at base of plant. Symptoms pronounced only during late spring.	Same as for virus diseases. Early removal of diseased plants necessary.
Crown and Cane Gall	Knobby galls or growths at crowns or along fruiting canes of black raspberries. Galls on roots or at crowns of reds.	Use healthy planting stock and uncontaminated soil for new plantings. Practice crop rotation.
Anthracnose	Grayish spots on canes and leaves. Dieback and blight of cane tips and fruiting shoots at harvest time.	Spray in delayed dormant stage with liquid lime-sulfur, 8 gallons in water to make 100 gallons of spray. Remove "handles" of young "tip" plants when new plantings are started.
Raspberry Byturus, or fruit worm	Tiny reddish-brown beetles skeletonize the newly-formed leaves. Larvae enter the young fruits and feed on the fleshy receptacles. Red raspberries are attacked more often than blacks.	When beetles appear spray plants thoroughly with 4 pounds of lead arsenate in 100 gallons water plus a spreader such as fish oil soap or sulfated alcohol.
Raspberry sawfly	Larvae colored like the foliage on which they feed, are about ¾ inch long and covered with barbed spines.	Spray with lead arsenate when larvae first appear.
Black-horned tree cricket	Canes weakened by rows of egg punctures.	Cut out and destroy all of the damaged canes while pruning.
Raspberry cane borer	In June young raspberry shoots girdled with two rings an inch apart. Later a larva burrows downward from the girdle.	Cut off the wilted tips a few inches below the girdle and destroy.
Red-necked cane borer	A gall-like enlargement on the cane caused by a spiral burrow of the larva.	Cut out and destroy all of the galls while pruning.
Raspberry cane maggot	A larva cuts a tunnel around the shoot just under the bark, girdling it from the inside. Wilted tips appear in May.	Cut out the wilted canes a few inches below the girdle and destroy.
Rose chafer	Long-legged yellowish-brown beetles about ½ inch long that feed on the foliage and fruit buds.	Spray with 2 pounds (50% wettable powder) DDT in 100 gallons of water.

INSECTICIDE AND FUNGICIDE CONVERSION TABLE FOR SMALL PLANTINGS

(Giving Small Quantity Dilutions for Home Fruit and Ornamental Plantings)

	Where and Why?	*Recommended Material*	Amounts to Use to Make the Following Quantities of Spray (*T = level tablespoon, t = level teaspoon*)						
			1 qt.	1 gal.	3 gals.	5 gals.	10 gals.	20 gals.	100 gals.
Dormant	Fruit Trees and Ornamentals *For:* Scale and Red Spider	2% oil	4 t.	5 T.	1 cup	1½ cups	1½ pts.	3 pts.	2 gals.
		3% oil	5 t.	½ cup	¾ pt.	1¼ pts.	2½ pts.	2½ qts.	3 gals.
		4% oil	1½ T.	⅔ cup	1 pt.	1½ pts.	1½ qts.	3¼ qts.	4 gals.
		5% oil	2 T.	1 cup	1¼ pts.	2 pts.	2 qts.	1 gal.	5 gals.
Summer	Aphids on Flowers and Shrubs	Nicotine or Pyrethrum 1 to 200	1 t.	4 t.	4 T.	6½ T.	¾ cup	1½ cups	2 qts.
		1 to 300	⅔ t.	2½ t.	2½ T.	4¼ T.	½ cup	1¼ cups	1½ qts.
		1 to 400	½ t.	2 t.	2 T.	3¼ T.	6½ T.	¾ cup	1 qt.
		1 to 500	½ t.	1½ t.	1½ T.	2½ T.	5 T.	⅔ cup	1½ pts.
		1 to 800	¼ t.	1 t.	3 t.	5 t.	3¼ T.	7 T.	1 pt.
	Codling moth, Grape insects	DDT (50% pwd)	1 t.	1 T.	3 T.	5 T.	¾ cup	1½ cups	1½ lbs.
	Oriental fruit moth	DDT (50% pwd)	1 t.	1¼ T.	4 T.	6½ T.	1 cup	2 cups	2 lbs.
	Grasshoppers and Ants	Chlordane (40% pwd.)	1½ t.	1½ T.	5 T.	8 T.	1¼ cups	2½ cups	2½ lbs.
Summer	Chewing Insects on Tree Fruits, Small Fruits, Flowers, and Shrubs	Lead Arsenate		3 T.	6 T.	10 T.	1¼ cups	2½ cups	3 lbs.
		Derris or Cube Powder		3½ T.	10 T.	1 cup	2 cups	4 cups	5 lbs.
Summer	Diseases: Scab, Brown Rot, Leaf Spots, Blotch, Etc.	Commercial Fungicides: Dry lime-sulfur (Post bloom sprays)			10 T.	1 cup	1 pt.	1 qt.	5 lbs.
		Commercial Fungicides: Fermate (Post bloom sprays)			⅓ cup	⅔ cups	1⅓ cup	2⅔ cups	2 lbs.
		Commercial Fungicides: Wettable sulfur (Post bloom sprays)			1 cup	1⅔ cups	1⅔ pts.	1⅔ qts.	8 lbs.
		Commercial Bordeaux	According to directions on container						
Summer	Cherry and Plum Leaf Spot	Fixed Copper (on basis of 50% metallic)			3 T.	5 T.	10 T.	1¼ cups	1½ lbs.
		plus							
		Fresh Spray Lime			6 T.	10 T.	1¼ cups	2½ cups	3 lbs.

Information About Spray Materials

DORMANT SPRAY MATERIALS

For dormant spraying the grower has the choice of either dinitros or petroleum oils, both of which contain many different types. These may be classified as follows:

1. Dinitros. Several different formulations (see text).
2. Dinitros with petroleum oil.
3. Petroleum oils.

   Two types, Regular and Superior. Either of these may appear in any of the following forms: (a) Concentrated or mayonnaise-type emulsions; (b) Miscible oils; (c) Emulsion oils; (d) Tank-mix oils.

DINITROS

Dinitros were first developed for controlling aphid eggs for which all formulations are very effective. More recently other uses have been found for them. Dinitro-o-sec-butyl-phenol (DN 289) is effective in controlling bud moth, light infestations of the different scales, European red mite eggs and pear psylla. Although the control of scales and mite eggs is not quite as effective as with oil, some growers may wish to use it as a fully dormant spray. Its combination with oil is not advised.

A water suspension of sodium dinitro-ortho-cresylate (Elgetol or Krenite) may also be used against bud moth and Psylla but is no control for scales or mites.

Others, such as dinitro-cyclo-hexyl-phenol, are used principally against aphid eggs.

DINITROS WITH PETROLEUM OILS

Dinitros (except DN-289) may be combined with oil for dormant spraying, although there is always a chance that some injury may occur. Early application of dinitro and oil will minimize this danger. This combination is very effective against all aphid eggs, European red mite eggs, and scale insects. Men and animals should be protected from excessive drift of spray.

PETROLEUM OILS

For several years the New York Station has done extensive work with many different oils. This has resulted in a division of the oils into two classes which are termed "Regular" and "Superior". The regular oils are those that have been used in Ohio for many years. Tests of the Superior oils in Ohio have been satisfactory although no definite recommendation is being made for their use at this time.

NEW YORK SPECIFICATIONS* OF OILS FOR USE ON FRUIT TREES IN DORMANT AND SEMI-DORMANT PERIODS

	Regular Type	*Superior Type*
Viscosity (Saybolt, at 100° F.)	90-120 seconds	
Viscosity index (Kinematic)	65 (minimum)	90 (minimum)
Gravity (A.P.I. degrees)	28 (minimum)	31 (minimum)
Unsulfonated residue (A.S.T.M.)	75 (minimum)	90 (minimum)
Pour point	Not greater than 30° F.	
Homogeneity	A relatively narrow boiling distillate portion of petroleum.	

* The following methods of testing spray oils are to be used: *Viscosity*: Kinematic, A.S.T.M. Designation: D445-39T. *Conversion to Saybolt Universal Viscosity*, A.S.T.M. Designation: D446-39. *Kinematic Viscosity Index*: A.S.T.M Designation: D567-40T. A.P.I. *Gravity*: A.S.T.M. Designation: D287-39. *Pour Point*: A.S.T.M. Designation: D97-39. *Unsulfonated Residue*: A.S.T.M. Designation; D483-40.

Two gallons of the superior type oil are used where three of the regular are required. Superior oils are generally safer for use when buds are unfolding, although damage has been noted if applications were made too late.

Oils, regardless of type, are widely used for dormant spraying due to their (1) low cost, (2) efficiency in general orchard cleanup, (3) noncorrosive action on spray machinery, (4) general agreeableness and (5) special necessity for mite control where DDT is used in the spray program. The different formulations of either "regular" or "superior" type oils are discussed as follows:

(a) *Oil Emulsions.*—These contain from 65 to 85 per cent oil and are usually purchased already prepared from commercial concerns. They may be stored for future use but must be protected from freezing and also from extreme heat. Emulsions may be home-made, but these generally do not store well and are less convenient and satisfactory, especially to the small growers. Since the content of actual oil is lower than in other formulations, enough extra must be added to the spray to make up the difference.

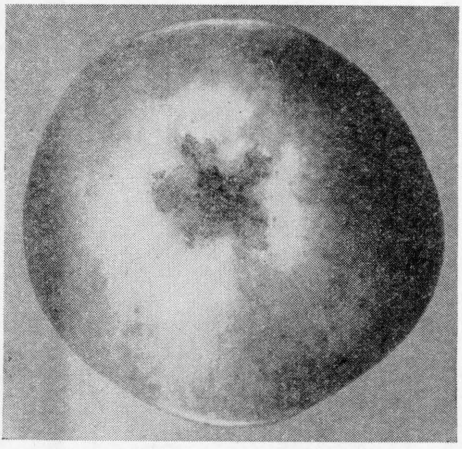


Fig. 26.—European red mite eggs in the calyx end of a mature apple. Dormant spraying with oil kills red mite eggs on the bark.

(b) *Miscible Oils.*—Oils of this type have the emulsifying agent dissolved in the oil and emulsify easily with agitation, forming very stable emulsions. They usually contain above 90 per cent oil. The oil deposit is very uniform and usually not as heavy as that effected by other types.

(c) *Emulsible Oils.*—These also have the emulsifier dissolved in the oil, and usually contain from 95 to 98 per cent of oil. They require good agitation to emulsify them in the tank, and have the advantage that they generally deposit more oil on sprayed surfaces than do the miscible-type oils. As these oils contain no water they will not freeze.

d. *Tank-mix Oils.*—This term is applied to oils which are emulsified by adding the emulsifier to the oil in the tank at the time of mixing. These oils should fall within the specifications given for "regular" and "superior" oils.

Motor oil or crankcase drainings are unsuitable for spray purposes. Two widely used tank-mix formulas are here listed:

Formula I. "Regular" lubricating oil	3	gals.
or		
"Superior" lubricating oil	2	gals.
Copper sulfate (fine crystals)	½	lb.
Hydrated lime	¾	lb.
Water to make	100	gals.

For a 200-gallon tank, double the foregoing formula; for 300 gallons, triple it; etc. This will give a 3 per cent spray of the "regular" type oil. For a 4 per cent oil spray, use 4 gallons of oil.

In making the tank-mix, place enough water in the tank to reach the agitator shaft. Then with pump running, place the copper sulfate on the screen and wash into the tank. Next, sift in the lime, followed by the oil. Continue pumping until all the oil is emulsified and no free oil shows on the surface. The tank is then filled with water, and without shutting off the engine proceed to the orchard and spray.

Formula II.	Lubricating oil	3 gals.
	or	
	"Superior" lubricating oil	2 gals.
	and	
	Blood albumin emulsifier	8 oz.
	or, goulac	6 oz.
	Water to make	100 gals.

This formula is prepared in the same order as Formula I. Sift the goulac or blood albumin into the small amount of water that is being pumped, then add the oil and continue pumping until emulsification is complete. Fill tank with water and spray immediately.

Either of the preceding formulas may be combined with 4-6-100 bordeaux mixture as an early spring dormant spray for control of peach leaf curl in addition to scale or red mite.

Cautions in Use of Petroleum Oil Sprays:

1. Some concentrated oil sprays stand freezing, others *do not.* Know the kind you are using and protect from cold if it is in the latter class.
2. Do *not* spray with oils if temperatures are below 40°.
3. *Do not* spray with free oil floating on top of the spray solution.
4. Oils are used most efficiently during the period that buds are swelling, but when the leaf tips begin separating use of the "regular" type oils should be stopped. Oils of this type used in the delayed dormant period sometimes cause injury. "Superior" type oils have a wider latitude of usage.
5. *Do not apply* dormant oils to apple trees in the fall because of likelihood of injury.
6. For best emulsification of tank-mix oils, in air-blast or speed sprayers having no mechanized agitation, try using less water while oil is being emulsified. If this fails, try increasing the amount of emulsifier.

SPRAY MATERIALS FOR SUMMER USE

Sulfur Fungicides

Sulfur fungicides can be grouped into two general types, namely: (1) combined sulfur, such as calcium, sodium, or potassium sulfides, and represented largely by lime-sulfur, and (2) uncombined or elemental sulfur. This second type or group may be subdivided further into the paste sulfurs, the dry wettable group, and sulfur dust. Following is a brief discussion of the sulfur fungicides in use and recommended in Ohio.

Lime-sulfur: This material, a few years ago, was considered to be the very best for use in apple scab control. It still controls scab as well as any other material, but now is considered too harmful for general use on apple foliage. It not only causes frequent burning of foliage and russetting of fruit, but actually causes a reduction in leaf area and leaf activity to the point where yields are reduced. Lime-sulfur is now recommended on apples only in the very earliest of the early spring scab sprays and need not be used even then.

Liquid lime-sulfur, when held over winter should be stored where it will not freeze, and sealed to exclude air. If there is any doubt as to whether such stored material is fit for use, or if it is off color, it may be tested with a Baumé hydrometer. A Baumé reading of 30-33° would indicate that little or no deterioration had occurred. Samples of about one pint may be sent to the Agricultural Extension Service, or to the Ohio Agricultural Experiment Station for testing if desired.

Flotation type sulfur: One of the most effective of the uncombined sulfur group is flotation sulfur. It is a sulfur paste made as a by-product in the manufacture of artificial gas. It is colloidal in nature, of very small particle size, contains some impurities, suspends well in water, and is cheap. Results of extensive experimental work indicate that this sulfur product can be depended upon for the control of apple scab even during the prebloom period.

There are several flotation type sulfur products on the market. They contain around 40 to 50 per cent sulfur and should be used in pre-bloom on apples at 12 pounds per 100 gallons of water and in post-bloom at 8 to 10 pounds per 100 gallons. On peaches the extremely blue colored type should be avoided for the late cover and pre-harvest sprays because of objectionable residue on the fruit.

In addition to the regular flotation sulfurs there are one or two prepared forms of sulfur pastes that physically resemble the flotation type. Magnetic 70 sulfur paste is one of these and is made by a special process of grinding sulfur in water. Tests have shown it to be equally as effective as flotation. Magnetic 70 contains 70 per cent of sulfur and should be used at 8 pounds on apples in the prebloom and at 5 to 6 pounds in the post bloom sprays.

Dry wettable sulfur: In addition to the paste forms of uncombined sulfur fungicides there are a large number of dry wettable sulfurs on the market. At first these materials were simply made by mixing a wetting agent of some kind with a relatively coarse ground sulfur (325 mesh or less). Improvements in the process of grinding have been made and there are now many brands of very finely divided wettable sulfurs on the market. For the sake of convenience and to differentiate these extremely fine particle size sulfurs, they are herein designated as *Microfine dry wettable sulfurs.* The microfine sulfurs are excellent materials and are now recommended interchangeably with the paste type sulfurs for fruit disease control. The coarser 325 mesh dry wettables are no longer recommended.

Sulfur dust: This material is simply a finely ground sulfur to which various conditioning agents are added as "fluffers". Sulfur dusts may be useful on stone fruits in special cases; but for apple, dusting has *not* been generally recommended.

Fermate

Fermate, the iron salt of dimethyl dithio-carbamic acid, is a relatively new organic fungicide. It has been thoroughly tested on a large variety of crops, however, and has been especially useful in the control of certain fruit diseases which cannot be controlled with sulfur. It is safe on most types of foliage and is compatible with most insecticides.

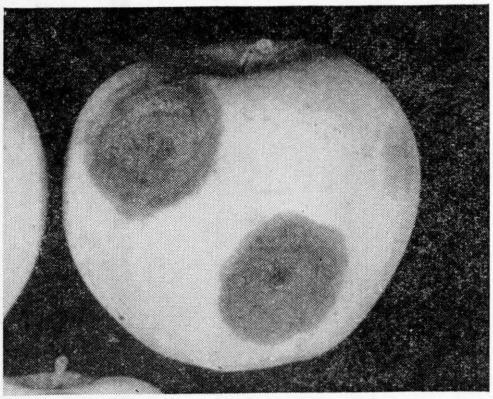


Fig. 27.—Bitter rot

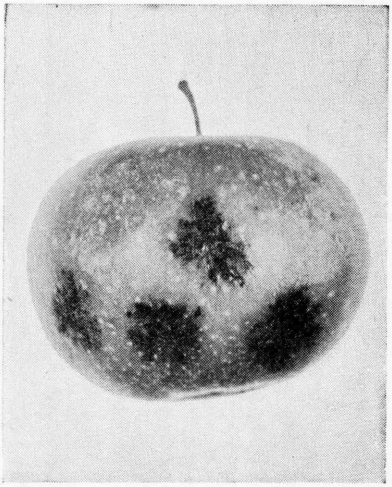


Fig. 28.—Apple blotch

These two diseases are controlled by Fermate, or bordeaux mixture.

Fermate is now recommended in place of bordeaux for the control of *apple bitter rot, blotch,* and *Brooks spot* in places where these diseases are damaging.

Karbam (black), reported to be essentially the same as Fermate, may be used wherever the latter is recommended.

Bordeaux Mixture

Bordeaux mixture is the oldest fungicide still in use on fruits. In the past it has been widely recommended and used for the control of almost all fruit diseases. It has one very serious drawback. Bordeaux has frequently caused severe injury to the foliage and fruit of plants. Because of this, a constant effort has been made to develop new materials which would control diseases and not cause injury. Fermate, for example is now being recommended instead of bordeaux for the control of apple bitter rot, blotch, and Brooks spot; and on grapes for black rot.

Bordeaux mixture is a combination of copper sulfate (blue vitriol), lime, and water. A 4–6–100 bordeaux formula, for example, means 4

pounds of copper sulfate, 6 pounds of hydrated lime, and 100 gallons of water. The most common method in use for the preparation of bordeaux is to dissolve powdered or instant copper sulfate in about two-thirds of a tank of water by washing it through a screen with the sprayer agitator running. Then with the agitator still running the hydrated lime may be sifted in slowly while the tank is being filled. If the lime contains any lumps it should be made into a thin slurry with water and poured through the screen. Only *fresh* lime should be used. If a coarser granulated, or lump copper sulfate, is used it must be dissolved in water first and then poured into the tank. The use of hot water will shorten the time required for dissolving the copper sulfate. In any case the required copper sulfate must be in solution and diluted with water before the lime is added.

For small quantities of bordeaux for garden use the copper sulfate may be dissolved in one-half the water and the lime mixed with the other one-half in separate buckets. Then the two can be poured together.

Fixed Copper Compounds

Many insoluble copper compounds have been developed as substitutes for bordeaux mixture. In general they are not quite as effective in disease control but are somewhat less injurious to fruit foliage.

There are two general types of these fixed coppers recommended for tree fruits: (1) The basic copper sulfate group, of which the tribasic forms are generally used, include such trade named products as Basi-Cop, Spray Cop, and Tri-Basic; (2) the basic copper chloride group includes copper oxychloride, copper oxychloride sulfate, and Copper Compound A. The trade named products mentioned have been tested in Ohio and the list is by no means complete. The chemistry of these compounds is extremely complex, and literally hundreds of chlorides and sulfates of copper can be made. Likewise, the concentration of copper varies with each, ranging from 12 to 56 per cent metallic. While there is some variation in their effectiveness and safety per unit of metallic copper, it is recommended that all spray formulas be calculated on a uniform copper basis. Ohio recommendations are based on the 50 per cent metallic copper content.

All fixed coppers may cause foliage injury and fruit russet on apples if applied before midsummer. For this reason they are *not* recommended on apple. They control cherry leaf spot better than any other material. Lime should be added as per schedule on cherry and plum.

Nicotine Sprays

Nicotine sulfate, used with a spreader-sticker, is an effective spray against aphids, (See Ohio Experiment Station Bulletin No. 464) or other soft bodied insects. It combines with most insecticides and fungicides, thus being well adapted for use in a general spray program. Its chief objections are (1) cost, and (2) discomfort to the operator in applying. *Fixed nicotines,* particularly in combinations with DDT, may be used against codling moth.

Lead Arsenate

Lead arsenate is the most extensively used stomach poison for controlling codling moth and other chewing insects in the orchard. That sold for tree fruits in the east is known as acid lead arsenate. This differs slightly in chemical composition from basic lead arsenate which is used on peaches on the Pacific coast. The acid lead arsenate is more toxic to insects than the basic form and is considered the more dependable for controlling fruit insects under eastern conditions. Powdered lead arsenate does not deteriorate with age. It should contain at least 30 per cent of arsenic pentoxide and not over ¾ of 1 per cent of water-soluble arsenic. The manufacture of lead arsenate is well standardized and there is little danger of getting an inferior product.

Lead arsenate has good physical properties for spraying and does not dissolve, but is held in suspension in water. It can be combined with fungicides, such as flotation type sulfur, lime-sulfur, Fermate or bordeaux mixture, and with summer oil and nicotine or with DDT, in making combination sprays. Lead arsenate adheres well as a spray, increasing its effectiveness, but this same quality prevents its being ideal for the purpose intended, because of the possible residue on harvested fruit.

DDT

DDT as an orchard spray is now well established in Ohio. Its use on apples has produced excellent control of the codling moth in all parts of the state. It is outstanding in the control of leafhoppers. It does *not* control curculio, or scale insects and seems to favor additional damage by the European red mite and the red banded leaf-roller. DDT kills predators and parasites that normally aid in the control of these pests. It is recommended for use only in orchards where a codling moth problem exists. See page 7.

On peaches, DDT controls Oriental fruit moth, plant bugs and rose chafers, but is very toxic to parasites of the Oriental fruit moth. Its use on peaches also tends to stimulate the abundance of European red mite and to a lesser extent the two-spotted mite.

Orchards to receive a summer schedule of DDT should have oil applied in *dormant, or green tip stage.*

Benzene Hexachloride

Benzene hexachloride has been shown to be an excellent substitute for lead arsenate in the control of the *plum curculio* attacking *peaches.* This insecticide is much more effective than lead arsenate against curculio and apparently does not cause injury to plant parts.

The principal objection to the use of benzene hexachloride is its tendency to cause disagreeable flavors in fruits and other food crops. For this reason it should *not* be used on apples for the control of curculio, particularly in late season. Taste tests on fresh, frozen and canned peaches have shown that the regular types of benzene hexachloride sprays can cause a disagreeable, musty flavor to peaches if the material is applied as close as 6 or 7 weeks to harvest. To insure a wide margin

of safety, regular type benzene hexachloride sprays should *not* be applied to peaches later than 10 days after the shuck-split spray.

The gamma content of regular types of benzene hexachloride varies from 6 to 12 per cent depending upon the method of manufacture. On peaches the 6 per cent gamma material should be used at the rate of 3 pounds in 100 gallons of water, the 10 per cent gamma material at 2 pounds and the 12 per cent gamma material at 1½ pounds.

There are several types of high gamma or "odorless" benzene hexachloride formulations on the market containing from 12 to 25 percent gamma isomer. These materials are much less likely to cause off-flavors than regular types although they fall within a higher price range at present. If the use of the "odorless" materials is desirable it is suggested that 12 percent material be used at 2 pounds, and the 25 percent material at the rate of 1 pound per 100 gallons of water.

MATERIALS FOR SPECIFIC PURPOSES, BUT NOT GENERALLY RECOMMENDED

Insecticides:

Natural, or synthetic cryolite is used only against the apple flea-weevil, see page 8.

Rotenone may be used against the Pistol case-bearer.

The *Dinitros* may be used in early season sprays (page 23) and modified and dilute formulations are recommended for European red mite control in the summer (page 31).

Chlordane (Dowklor, Octaklor, etc.). Excellent for control of grasshoppers. Its only other recommended use in the orchard is against rose chafer and curculio on stone fruits (see pages 8, 12, and 16).

Chlorinated camphene (Toxaphene, Penaphene, etc.). Recommended in the orchard only for grasshoppers.

Hexaethyl tetraphosphate (HETP). A very poisonous material that can be used against mites and the 17-year cicada. Handle with care.

Tetraethyl pyrophosphate (TEPP). More poisonous than HETP. It can be used against mites and cicadas, but is suggested only for experimental blocks, or emergency use as for cicadas.

Parathion (Thiophos 3422). Another very poisonous compound. It is effective against many pests, but should be used only under special circumstances. It is *not* ready for general recommendation.

DDD ("Rothane"). For emergency against red banded leaf-roller.

Fungicides:

Puratized Agricultural Spray: This is an organic mercury compound which has now been widely tested for apple scab control. It is an effective material and may be used during the *early* part of the season if desired. Because of its mercury content it is *not* being recommended for late season application where residue may be a problem. It does have some eradicative action on *foliage scab.*

Phygon. This is an organic quinone compound. It is a powerful fungicide and has controlled scab well. It has, however, caused a type of fruit spotting and a yellowing of foliage, and cannot be recommended.

Control of Mites in Orchards

Several species of mites may be found attacking the foliage of different fruits. In Ohio, however, by far the most harmful species is the European red mite. As this pest over-winters in the egg stage on the twigs and branches of trees it can be attacked best in the dormant period by the use of oil sprays. *This is a basic control measure and where mites are a problem should never be omitted.*

However, despite the effectiveness of the early season oil sprays, mites frequently become abundant and injurious during mid-summer and must be attacked by other sprays. At present there is no ideal material (acaricide) that is available for use. Fortunately, there are a number of materials, that when used intelligently and thoroughly will give satisfactory control of the active mites. They do *not* kill the eggs, and for that reason frequently have to be repeated. These materials and their characteristics are listed on page 8 under "emergency sprays for apple." These recommendations apply to peach, as well as to apple, with one notable exception. DN Dry Mix No. 1 should *not* be used on *peaches,* since its use may result in serious foliage injury. DN-111 probably is the most satisfactory material for use on peaches as it gives excellent control of the two-spotted mite in addition to giving fairly adequate control of red mite.

Suggestions Concerning Spray Practices

PROTECTING THE FRUIT

Weather and Mechanical Injury

Weather Injury. — Weather injury to fruit and foliage is often confused with spray injury. Low temperatures and frosts during the blossoming period and early part of the growing season may cause varying amounts and kinds of russet injury. Often this injury takes the form of a belt of russet around the apple following severe freezing injury or irregular russet patterns following less severe frost injury. (See Fig. 29.)

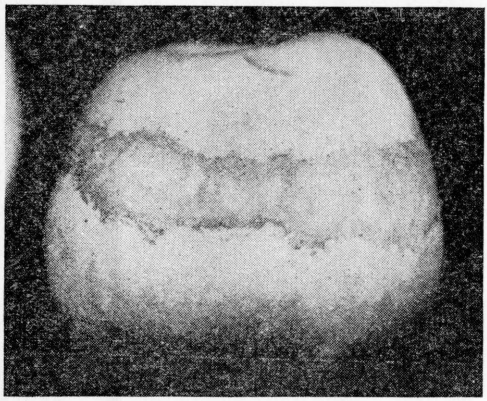


Fig. 29.—Russet ring caused by frost, when apple was very small.

Leaves may be injured by frost so that dwarfing and crimping develops, and, when severely injured, blisters may develop on the under-surfaces. Leaves so injured often turn yellow and drop prematurely.

Extremely hot weather sometimes causes sunburn on the fruit. This is manifested by a discoloration and in extreme cases by a blistering and cracking of the skin on the exposed area. Very hot weather may also cause a bronzing of red tones and a whitening of green color tones.

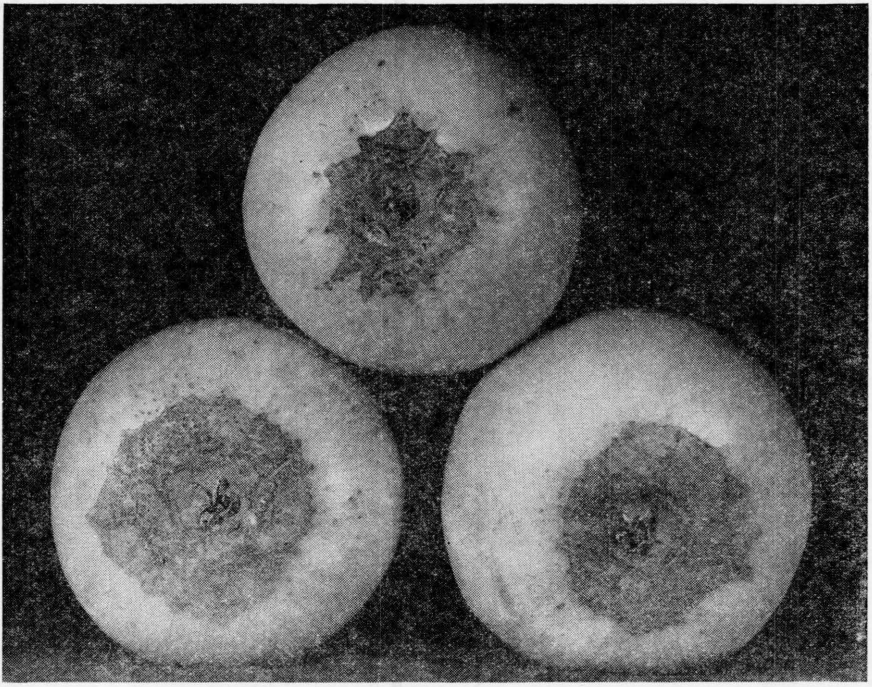


Fig. 30.—Frost injury around calyx end of apple.

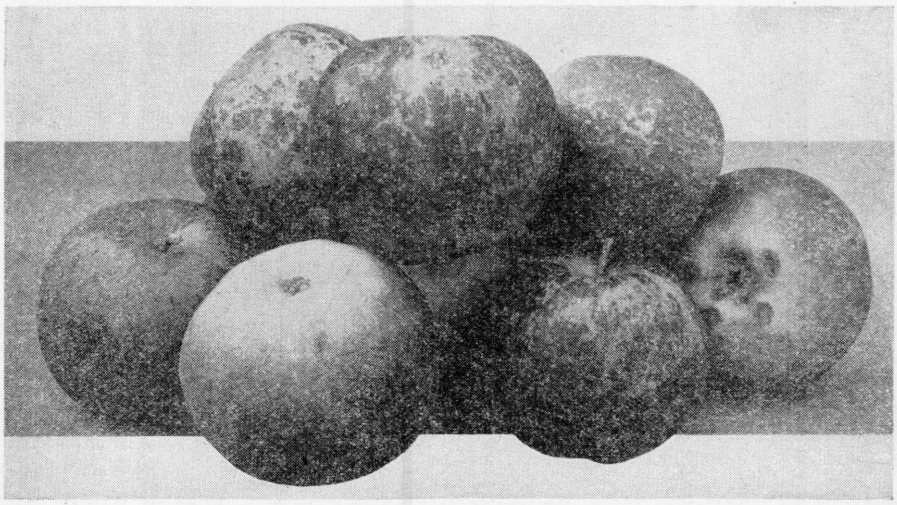


Fig. 31.—Fruit showing the effects of spray and weather injury.

Mechanical Injuries.—Mechanical injury to the foliage and fruit comes from the improper use of spray equipment, poor break-up of the liquid, coarse particles in the spray material, and drenching of the foliage. It appears in the form of russeted fruit, dwarfed or torn leaves, and in part accounts for the lack of finish and quality of fruit in many orchards. Prevention of these injuries may be secured by following the recommended spraying methods.

Spray Injury

Spray and weather injury may be very similar in appearance and frequently it is necessary to examine an unsprayed tree before the correct amount of spray injury may be determined. Spray injury develops when improper materials have been used, or when the right materials have been applied in the wrong way, or if allowed to stand in the spray tank too long before application or when weather favors injury. Varieties vary greatly in their susceptibility to spray and weather injuries. (See table, page 10.)

Trees lacking vigor are injured frequently by spray and weather conditions, whereas vigorous trees are not affected so easily. Similarly, foliage that has been injured previously by insects, diseases, hail or wind whipping, is more susceptible to spray injury than healthy foliage. Accordingly, orchards which are maintained in a healthy condition are injured less frequently by spray materials or adverse weather conditions.

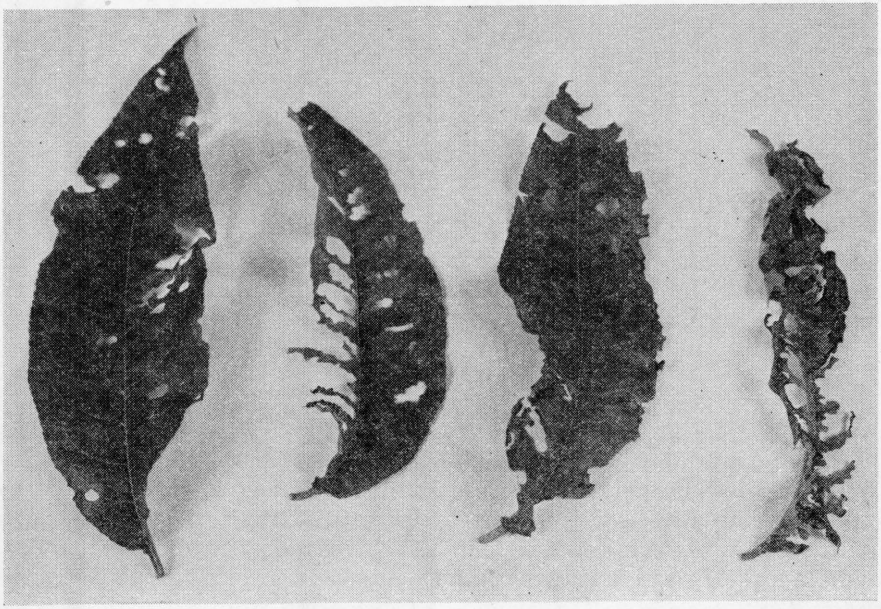


Fig. 32.—Arsenical injury to peach.

Order of Mixing Spray Materials in the Spray Tank

In practically all situations in which spray materials are to be mixed, start with from 10 to 40 gallons of water in the tank. Have the spray pump running in order to provide agitation.

Instructions for Mixing Different Spray Combinations

1. *Dormant oil sprays.* (See pp. 23 and 24.)

2. *Lime-sulfur lead arsenate combinations.* This combination, though no longer recommended is still used by some growers. The lime-sulfur should be put in the tank first, then the lime. When the tank is almost full the lead arsenate is added. *Spray at once.*

Since sulfur and lead arsenate react with each other they should never be mixed until ready to spray. *Always add* hydrated lime if lime-sulfur is the fungicide used.

3. *Bordeaux combinations.* Copper sulfate should be placed in the tank first and this followed by the lime with the sprayer running. Other materials should then follow with the lead arsenate, or DDT added last, when the tank is almost full.

4. *DDT* is compatible with all fungicides, *except* lime-sulfur. The mild sulfur fungicide is placed in the tank first and DDT added as the sprayer is filling. *No lime* should be added to DDT sprays, except as carried in necessary bordeaux sprays.

5. Materials that foam badly should *not* be added until the tank is nearly full of water.

Use of Spreaders and Stickers

Extensive data taken in many experiments show that little or nothing is gained by the use of spreaders, or wetting agents in tree sprays. It is true that such materials reduce surface tension so that the spray material spreads more uniformly. However, the wetting agent present in some cases accelerates spray material run-off during subsequent rainfall.

Some of the materials on the market are combination spreaders and stickers. They are supposed to not only facilitate even spread of the spray material, but also to increase adhesiveness after they have once dried on the tree. Some spreader-stickers actually do this and increase the build-up of materials and the probable length of time they remain effective.

There are a few materials being sold which are strictly "stickers". They do not increase the uniformity of initial coverage, but do increase the adhesiveness of fungicides and insecticides.

The use of stickers, and the combination type of spreader-sticker should theoretically be worthwhile. However, experiments have shown that in most cases the extra cost of the "spreader-sticker," or "sticker" over-balances the advantages gained by their use. They are recommended only in special instances as for grapes, and at times for use on plums.

Amount of Spray Required for Coverage

Records of the amount of spray solution required in the Experiment Station orchards have been kept over a long period of years. During this time the spraying was done under the direction of the same man. The sprayers used have been of moderate capacity ranging from 15 to 35 gallons per minute, and carrying pressures of 500 pounds or more. In these orchards trees less than 12 years of age were pruned in such a manner as to leave them moderately dense, while the trees of full bearing age were more openly pruned.

The data submitted in the tables following are taken from the spraying records in those orchards. The amounts of material per tree used at Wooster have at all times corresponded very closely with the amounts used in the orchards of the various sub-stations and county experiment farms. The figures given are not intended as arbitrary recommendations to be followed in every case, but suggestive of the amounts found necessary for good results under the conditions previously mentioned.

Growers are cautioned when changing from one type of discharge nozzle to another or from one rate of pressure or volume to either a higher or lower to make sure that they are securing proper coverage.

Users of the air-blast type of sprayers should bear in mind that the amount of solution required to adequately cover a tree is essentially the same as when the conventional type high pressure sprayers are used.

Gallons of Spray Solution Applied per Tree (Wooster)

Age of Trees	Average Amount per Application for Season in Gallons			
	Apples	Peaches	Sour Cherries	Sweet Cherries
2 to 3 years.....	.5	.7	.5	.5
5 years	1.5	3.0	2.5	1.5
10 years	6.0	5.5	6.0	6.0
12 years	8.0	6.0	8.0	8.0
15 to 20 years.....	12 to 20	6.0	10.0	10.0
21 to 25 years.....	20 to 35		12.0	15 to 18

Estimate of Materials for Season

It is desirable to have an adequate supply of materials on hand before the season starts. Losses sometimes occur because of delays in securing materials at times when prompt application of these materials is necessary. To estimate the amount of materials needed for the season it will be necessary to determine the program to be followed, number of sprays, materials to be used, and the dilution. Then, by using the amount applied per tree, as shown in the table above, it will be relatively easy to estimate the amount of materials required to spray a given number of trees. Appreciably more material is required for the after-bloom than the pre-bloom applications.

Custom Spraying

In communities having many small orchards and vineyards the spraying with small individually owned spray pumps often results in unsatisfactory pest control. Large truck mounted, or tractor pulled sprayers owned by a custom sprayer who knows how to spray properly and is familiar with the materials and time of application, can service many orchards. In most cases the results are a definite improvement in the market quality of the fruit in the community serviced by this sort of an arrangement.

The most satisfactory results are obtained where the operator supplies the materials and charges the grower on a per gallon basis for the material applied with a flat rate as a minimum charge.

Spray rigs equipped to spray potatoes and vegetables as well as tree fruits are operated more profitably than those equipped only for spraying trees. This arrangement enables the owner of the sprayer to operate his outfit over a longer season.

DEFINITE PROCEDURE IN SPRAYING

Methods of Spray Application

The sprayman himself is the most important factor in getting a spraying job well done. He must start each needed application on time, finish on time, and use equipment and methods skillfully. There is no substitute for a skillful, alert, thorough working sprayman, who will thoroughly spray inside and out, top to bottom, with finely broken spray fog to give safe uniform coverage. It is relatively easy to get a good spray job with small trees. Larger, older trees are more difficult to cover. It is rare to find a sprayman giving thorough coverage to the upper third and top center of trees over 20 feet high. The top centers of such trees are especially difficult to cover. Scab and worms too often tell the sad story of failure to spray the upper third of the tree thoroughly. Inadequate gallonage is also responsible for many spraying failures.

The top central third of mature trees, often called the "pest nest" requires special attention. After most so-called thorough spray applications, the top often carries a third less spray material than the bottom. If the sprayman applies the material by standing on the rig, the lower limbs too may be unsatisfactorily covered. This does not mean that the sprayman should necessarily walk through his orchard, but rather suggests that he take particular pains to spray the lower branches. This application is especially true for the dormant spray, and it is desirable that he spray as much as possible for the underside of branches in order to hit the eggs of the red mite.

Multiple cluster nozzles or fog drive brooms may not place enough spray material in the tops. They can often be covered best with large capacity single nozzle spray guns. A tower on the rig is often needed to

get a good job on tree tops when spraying from a moving machine. It is advisable to lower the tops of trees that are too tall to spray thoroughly by heading back branches that are too tall. It is also advisable to prune away underhanging branches and thin out any dense areas to permit thorough penetration of sprays. Effective insect and disease control demands thorough timely coverage, and the tree pattern must lend itself to permit quick, thorough spraying. Large trees with bushy interiors and branches hanging to the ground cannot be covered by any practical method of spraying.

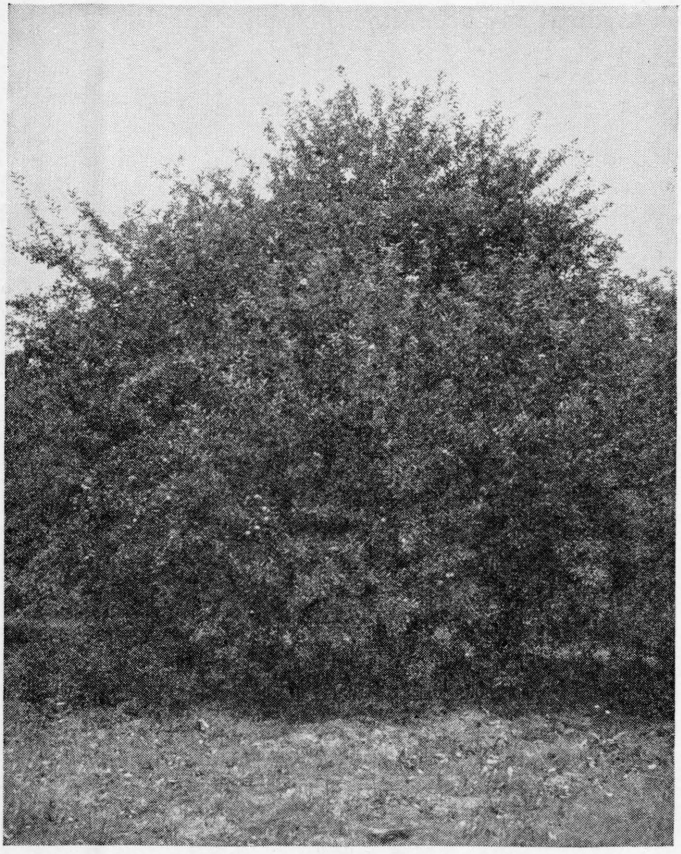


Fig. 33.—Too dense to spray thoroughly.

Fog drive guns or brooms in good order with satisfactory working pressure have given no mechanical injury when fruit and foliage is sprayed almost to the orifice of the nozzles. Single nozzle guns on the wide fog adjustment were usually found safe to within 3 to 5 feet of the nozzle. When wide open to get distance or height the single nozzled guns were seldom safe closer than 10 to 15 feet from the branches. The single nozzle gun can be a hazard to the orchard in the hands of an inexperienced sprayman, but is satisfactory when operated by an experienced, alert sprayman. It has its place when trees are sprayed from the ground, and for spraying the tops of all trees from a tower.

Spraying from the tops of portable rigs where practicable is most convenient for the sprayman. It permits the use of broom and gun combination that takes the capacity of the larger pumps, giving the sprayman more gallons per minute to handle than any other method. It has marked disadvantages, however, in working against wind. It is also

often difficult to secure satisfactory penetration of spray from all angles and thoroughly spray the interior of trees. Applications must be completed on time and methods employed to secure prompt complete coverage.

Commercial apple orchardists in Ohio should use equipment and methods that provide for a complete application in three days or less. This is especially true for apple scab sprays. Occasionally a critical scab spray must be applied in about 24 hours time for best control.

Selecting the Sprayer and Equipment

Size of Pump.—To determine size of spray pump for the job, figure gallonage requirements for one application and secure pump with sufficient gallons per minute capacity to apply the spray solution in three working days or less. Convenient water supplies, orchard filling stations, or hauling water to sprayer promotes the most efficient use of portable spray pumps. Stationary spray pump installations permit almost continuous use of spray pump capacity. Portable sprayers seldom deliver on the trees more than half the rated pump capacity in a day's time due to delays and inefficiencies. The number of gallons applied per day by a portable sprayer can be about doubled where a supply tank is used to refill sprayer where emptied in the orchard.

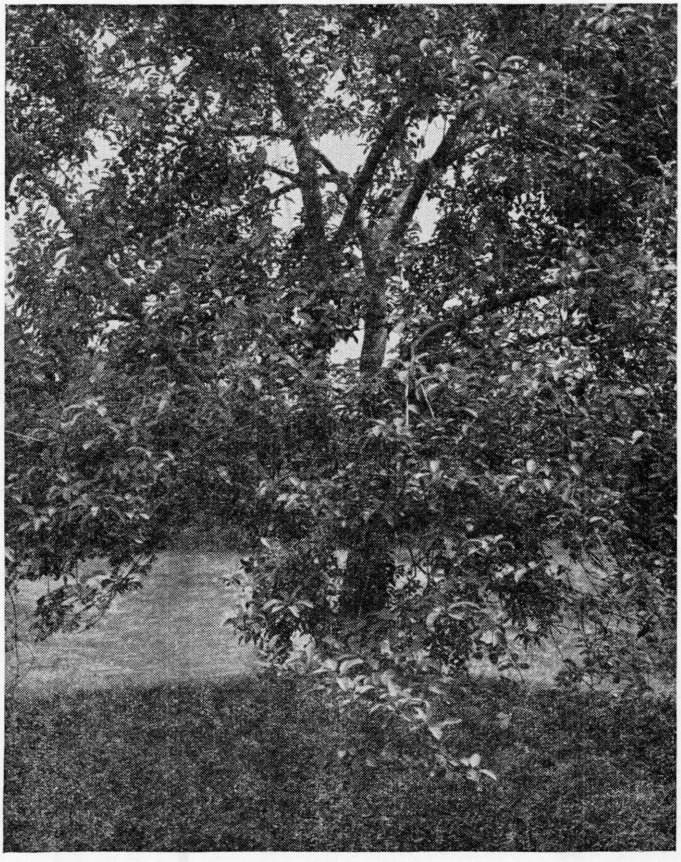


Fig. 34.—Properly pruned for spraying.

Size of Pumps Needed for Given Quantities of Spray

Spray material required for one application	Pump size required in gallons per minute on portable rigs
Less than 500 gallons.....	Hand pumps
500 to 3000 gallons.....	Power pumps rated up to 10 gallons
3000 to 6000 gallons.....	Power pumps rated at 12-15 gallons
6000 to 10,000 gallons.....	Power pumps rated at 15-22 gallons
Above 10,000 gallons.....	Power pumps rated at about 35 gallons or more, according to need

Select tanks for portable rigs as large as can be pulled to advantage to save time in refilling. Sufficient reserve power on power take-off rigs to pull the filled sprayer over the most difficult areas and to provide sufficient horsepower to drive the pump efficiently should be available. It is desirable to check on the pump occasionally to determine gallons per minute actually delivered through hose and nozzles. Time required to empty tank also will give the gallons per minute discharged. Many rigs, especially after some use, are found to deliver far less than the rated pump capacity. Attention should then be given valves, packing, leaks, etc. Restrictions in pipe lines and size or condition of hose or fittings or use of nozzles with too small discs prevent discharge of pump capacity. Keep your pump efficient.

Pressure.—Pressure at nozzles of 350 pounds or more on power rigs has given good break-up of spray fog and most economical coverage. High pressures are limited only by added power costs and ability of hose and equipment to withstand the higher pressures. Higher pressures generally give best fog break-up with least mechanical injury and most satisfactory coverage for the gallons applied.

Many pressure gauges, especially the older ones, have been found inaccurate in the orchard. Over 60 per cent of the gauges checked at work in Ohio orchards registered incorrectly. Gauges often indicated 200 pounds or more pressure than was actually carried in the hose line. Frequently by the time the loss of pressure is detected poor coverage has resulted, and excessive run-off has contributed to a sizable waste of spray material.

Capacity of Spray Guns.—There is a place for both single guns and multiple fog-drive guns or brooms. Combinations of both are often effective, using the single gun for treetops and where thorough coverage with brooms is difficult or impossible.

Capacity of Single Nozzle Spray Guns in Gallons per Minute

Pounds pressure	Diameter of discs—Fraction of inch					
	3/64	5/64	3/32	7/64	1/8	11/64
300	1.1	2.4	2.7	4.3	5.6	9.4
400	1.2	2.7	3.0	4.8	6.3	10.9
500	1.3	3.0	3.3	5.3	7.0	12.3
600	1.4	3.2	3.5	5.7	7.7	13.6

Capacity of "Fog-Drive" Guns in Gallons per Minute

Total discharge capacities of fog-drive guns which are regularly equipped with discs with 4/64 inch diameter holes.

Pounds pressure	3 Nozzles	4 Nozzles	6 Nozzles	8 Nozzles
300	4.1	5.5	8.2	11.0
400	4.7	6.3	9.5	12.6
500	5.4	7.2	10.8	14.3
600	5.9	7.9	11.9	15.9

5/64 inch discs give ⅓ more capacity and 3/64 inch discs give ⅓ less capacity than is indicated in the above chart.

Inefficient discharge of the rated capacity of spray pumps often results from wear on parts of the nozzle, such as discs and whirl plates. Worn-out nozzles and a disc too large for the eddy chamber of the nozzle result in coarse wasteful sprays. Adjustment of discs in the nozzle should be made as needed to conform to the rated capacity of the spray pump. Single or double nozzled guns in fog drive brooms up to six nozzles can be used for ground spraying. Higher pressure pumps of large

Fig. 35.—Spray gun in operation.

capacity are now permitting smaller, lighter hose for ground spraying, such as ⅜-inch. It is not necessary to use larger than ½-inch hose for ground spraying. The shortest length of hose for ground spraying should be 50 feet and many use up to 100 feet or more for hillside spraying.

A longer hose than 50 feet may be a burden to carry and usually would be unnecessary. For tank spraying, hose should be as short as it is convenient to handle, and large enough to carry capacity of the fog-drive broom used. Usually short lengths of ¾-inch hose are used for tank spraying with brooms of 8 nozzles or more. A swivel that does not leak is a handy device to place between gun and hose to prevent twisting and kinking of the hose.

Fig. 36.—Spray mast of perpendicular type.

Spray Masts.—Fixed booms or masts are now available from some manufacturers. These are being improved and will do many spray jobs well, especially in peach and cherry orchards and where trees are not too large or too dense. They are not adapted to pumps of less than 35 gallons or less per minute capacity and do best on those of 50 or more gallons per minute. Adjustments of nozzles should be made to spray tops thoroughly. Check on penetration of spray drive, as many large trees need more open pruning for this equipment to be effective. Masts at the rear center of the rig cover all outward terminals best and can be adapted to direct spray forward or back for thorough coverage. Forward speed of sprayer needs close checking to get needed gallonage on trees.

Speed or Air-Blast Sprayers.—Many speed or air blast sprayers have been purchased in recent years for use in larger Ohio orchards. When used properly they do a satisfactory spraying job at a great

saving in spraying labor. A powerful motor driven fan discharges a strong air blast back of a bank of nozzles. These nozzles are fed by a large capacity low pressure centrifugal pump. The spray is driven through the trees as an enveloping fog drive. The tractor operator can manipulate the sprayer, although many users prefer a second man to operate the nozzle banks to suit individual tree requirements. These rigs usually deliver more than 50 gallons of spray fog per minute, and a tractor pulled supply truck is needed to refill the sprayer where it empties to get efficient operation. One of these outfits can replace up to three large capacity high pressure rigs at a great saving in labor. Trees must be well pruned if mature to get thorough coverage with the air blast sprayer, and the rig must be driven slow enough to get adequate gallonage on the trees. Air blast sprayers work well against the wind providing they drive the spray clear through the trees. The wind may puff back much of the spray which improves all around coverage.

Two-way heads can be supplied for peaches and cherries to drive spray to rows on each side of the rig. While one may operate a speed sprayer and those equipped with a spray mast, the equipment does not in itself guarantee good spraying. When improperly operated these labor saving types of sprayers can do a poor job of coverage and lead to disappointment. They require an experienced spray man to operate them and should be regulated both as to adjustment of mast or head, and speed of tractor.

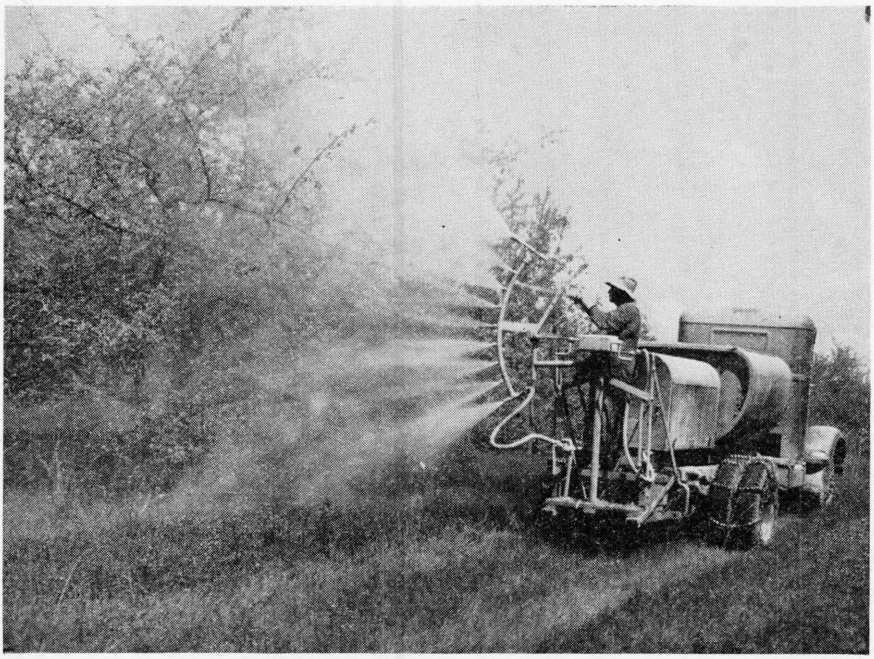


Fig. 37.—Spray mast "arc" design.

Concentrate Sprayers and Mist Blowers

Much work has been done and is now in progress in the development of concentrate sprayers. By the term "concentrate sprayer" is meant a spray applicator which will apply fungicides and insecticides in concentrated form. Instead of using 100 gallons of water to carry a certain poundage of the pesticide, such an applicator may use only 20 or even 10 gallons to carry the same amount of material. Such a machine will apply proportionately fewer gallons of spray to a tree.

The advantages of such a machine in saving of labor and water are obvious. However, the use of such small amounts of water as a carrier for the pesticides brings new problems.

Instead of covering a tree until the spray drips freely, it is necessary to cover the foliage and fruit by more or less standard sized droplets. The size of these droplets are important. In the first place, they must be small enough and spaced evenly to give uniform coverage. Secondly, it has been definitely proved that droplets must be of sufficient size to settle on and adhere to the leaf or fruit. Minute, drifting droplets do *not* settle where they are supposed to and do *not* adhere. Therefore, the machines described by such terms as misting, fogging, or vaporizing may distribute sprays that will be entirely ineffective, particularly in the application of fungicides. There seems to be ample evidence that concentrate sprays must be put where they belong, such as is done with regular sprays, and no dependence be placed on drifting types of application.

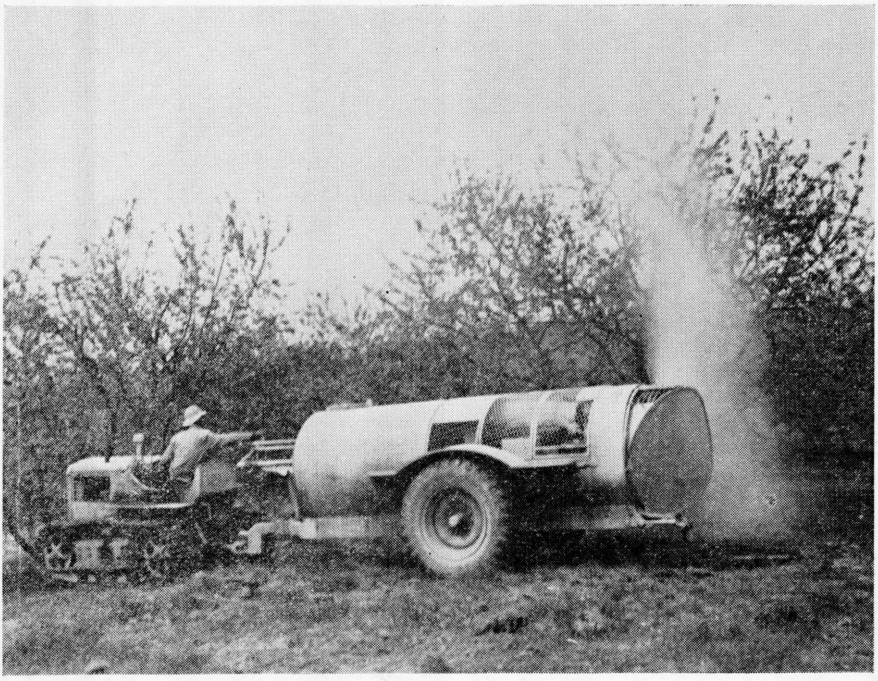


Fig. 38.—"Speed" or air-blast sprayer.

The use of concentrates increases the danger of spray injury unless the gallonage and distribution of it on the tree are strictly regulated. It is because of these unsolved problems that the use of concentrate spraying is *not* yet recommended.

At the present time there are numerous concentrate sprayers in the process of development. Some are being offered for sale. Several of the machines are promising and it is hoped that their use can be recommended soon. In the meantime, growers should be very cautious about buying a concentrate sprayer.

Equipment for Night Spraying

High winds and occasionally high temperatures during the day often interfere with proper application of sprays and dusts. The time may be so limited that the equipment at hand is inadequate to cover the orchard in the required time, working only during the day. Since the wind often dies down about nightfall, conditions at night are generally more favorable for spraying and dusting than during the day. However, on occasional nights the humidity is so high and the rate of drying of the spray so slow that the spray may not dry until morning. Under these conditions very severe burning and russeting of foliage and fruit may occur. Where spraying is being done at night the operator should make certain that the spray is drying on the trees in a moderate length of time.

Night applications are limited to situations where the operator rides the moving spray tank or duster. In order to spray at night a light must be provided on the sprayer. A single electric headlight bulb attached to the top of a pole, elevated above the operator's head at about the center of the spray machine, has been found to give satisfactory lighting for night spraying. Electricity may be supplied by an ordinary storage battery, charged with an automobile generator operated by the sprayer engine or by the tractor drawing the sprayer.

Care of the Sprayer

The proper care of the sprayer does much to increase its useful life. At the end of each day's spraying, water should be pumped through the spray pump, hose, and nozzles to clean out all chemicals. At the close of the spraying season, the pump, hose, and all equipment should be thoroughly cleaned with water and drained. The hose, rods, and guns should be taken off the sprayer and looked over carefully, and any needed repairs made. Nozzles should be cleaned and oiled. The pump should be filled with oil and parts apt to corrode should be cleaned and coated with grease before the rig is put away for the winter.

The use of 2,4-D weed killer in commercial sprayers to be used for insect or disease control is not recommended. It is almost impossible to wash all of this material from the tank, resulting in abnormal foliage following its later use in applying the regular sprays.

Water Supply System

A water supply system, set up so that the sprayer or supply tank truck can be filled quickly, is necessary. It is also advisable that the source of the water be only a short haul from the orchard. Locate supply tanks in the center of each 20-acre block of orchard. In most cases the water can be pumped at the source of supply into one tank, and piped from there by gravity to supply tanks located at convenient points. Tanks should be set up so that they serve as overhead filling stations with a large 2- to 4-inch discharge pipe equipped with a gate valve for quickly filling the sprayer. Where a pond or stream is used as a water supply, a tank filler helps in filling the sprayer quickly. The actual spray application methods used must be worked out to fit the needs of each orchard.

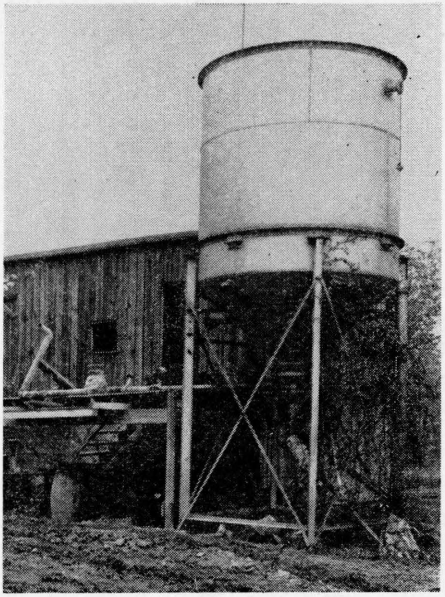


Fig. 39.—Water supply tank and loading station.

When necessary, the sprayer should be thoroughly overhauled during the non-spray season to have it ready and dependable when spray operations must be underway. The pressure gauge should be tested occasionally for accuracy and all valves and other worn parts replaced as necessary. The use of abrasive spray materials should be avoided. Hexaethyl tetraphosphate and tetraethyl pyrophosphate sprays, as sold for red mite and cicada control, sometimes injury the lining of certain types of spray cylinders. Your manufacturer, or spray machine service agent should be consulted before these phosphorus carrying insecticides are used in your sprayer.

DUSTING

GROUND:

Apples.—Dusting apples for controlling insects and diseases has been thoroughly tested in Ohio and has limited application. It frequently will suffice as a control program when the orchard is coming into bearing, but in mature orchards dusting of apple and pear trees is now limited chiefly to supplementary applications for scab control.

A duster may be drawn through an orchard where mud interferes with the movement of a heavy sprayer. Also dusts can be applied for scab control during light rains when liquid spray applications cannot be made. The ratio of dust to liquid spray required per tree would be about 1 pound of dust substituted for each 4 or 5 gallons of dilute spray required. The exact amount will vary with size of tree, but 15- to 20-year-old apple trees will require 2½ to 4 pounds of dust per application.

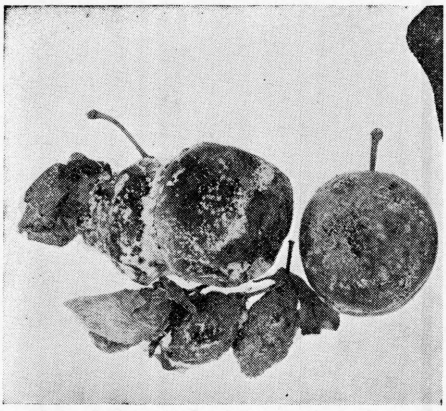


Fig. 40.—Brown rot disease is a major problem with the plum (above), peach, and cherry, especially a few weeks before harvest. It affects fruits and shoots. Some fruits may remain attached to tree as mummies over winter. They should be removed and burned. It can be controlled by sulfur as spray or dust.

If a summer dusting program is followed in a mature orchard it should be tried only in orchards *not* seriously infested with codling moth. It will be necessary to apply the dusts at weekly, or 10-day intervals if rains are prevalent. In the post-bloom period a mixture of 80 parts of finely divided dusting sulfur and 20 parts of lead arsenate is suggested.

Growers whose plantings do not justify the ownership of both a sprayer and duster had better place their dependence on spraying.

Other Fruits.—Dusting of peaches, plums, and sweet cherries for control of brown rot has produced good results, and is a method highly recommended where the application is properly timed. When a fungicide and insecticide are needed, a 65-20-15 sulfur-lime-lead arsenate combination is recommended, except on plums where insecticides are not recommended in dust form. If a fungicide alone is needed, as in late applications, a 90-10 sulfur-lime mixture is preferred.

AIRPLANE:

Some interest has been shown in the possible use of the airplane for orchard dusting. Limited tests have been made in Ohio of dusting by airplane for apple scab and codling moth control. The results were greatly inferior to those secured by ground applications. Until more experimentation is carried out, and more encouraging results are secured, we cannot recommend this method of application.

Troubles Combated by Methods Other Than Spraying

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Fire Blight

Blight of blossoms, twigs, limbs, and fruits are all manifestations of the disease "fire blight." The bacteria causing fire blight overwinter in "hold-over" cankers on the trunk and limbs which result from the advance of the bacteria from infected twigs, spurs, suckers, and sprouts.

A preventive spray of 1-3-100 bordeaux mixture at blossoming time has checked the spread of blossom blight on apple and pear. Usually this spray is applied when about three-fourths of the blossoms are open.

On apple, the larger blighted branches and cankers should be cut out in the fall, or winter. If limbs should be saved, treat the cankers with the fire blight canker solution. Check closely for cankers on limbs and trunks that may have resulted from infected spurs, water sprouts, or shoots.

Fire Blight Canker Solution.—To 3 ounces of concentrated hydrochloric acid add 1 quart of hot water in an enamel kettle, and in this mixture dissolve 9 pounds of dry zinc chloride powder. Commercial grades of chemicals are satisfactory for this solution. Add sufficient red or blue coloring, using a dye such as the Diamond brand, easily secured from local drug store, so that areas treated can be checked for thorough work. After cooling, pour the above solution into 7 pints of denatured alcohol and mix thoroughly.

Store in tightly stoppered large glass bottles or jugs to prevent evaporation. Apply with small paint brush.

When still small remove all spurs, shoots, suckers, and water sprouts from the crown, trunk, and large branches. This will tend to prevent cankers.

A soil management program involving sod and limited use of nitrogen fertilizers will aid greatly in checking fire blight. Excessive nitrogen fertilizers favor fire blight.

In the case of pear, removal of the blighted twigs, shoots, and spurs as soon as observed is the best method to prevent rapid spread of the bacteria into the larger branches and trunk. Following bloom, pear trees should be inspected every two or three days and blighted portions cut out. Cuts should be made at least 6 inches below the affected portion. The tools and cut portions should be disinfected with a solution made by dissolving two tablets of bichloride of mercury and two tablets of cyanide of mercury in one quart of water. A rag or sponge tied to the end of a stick makes a convenient swab for the larger pruning shears or saw. This mixture should be carried in a glass or wooden vessel. *It is extremely poisonous and should be kept out of the reach of children and livestock.*

A soil management program involving sod with inorganic nitrogen (never organic) added only in sufficient amounts to maintain moderate growth should be established. In establishing young orchards the intermediate stock Old Home should be purchased, and the desired variety grafted or budded on the branches 18 or more inches from the trunk.

Cherry Yellows

Cherry yellows is present in most of the larger sour cherry orchards in Northern Ohio. A complete survey for it has not been made and just how widely the disease is distributed in other parts of Ohio is not known at present. It must be assumed, however, that yellows may occur on sour cherry any place in the state where this tree fruit is grown. Cherry yellows is caused by a virus and symptoms of this disease have often been confused with spray injury, particularly copper injury. They have also been attributed erroneously to various physiological and adverse soil conditions.

Symptoms.—The symptoms are green and yellow mottling of some leaves followed by defoliation three or four weeks after petal-fall. Other symptoms are reduced spur growth, large leaves, and reduced yields of large size but good quality fruit. The mottling may vary from a light green chlorosis to leaves entirely yellow. Usually, at least some of the leaves show green areas along the veins and midrib and this characteristic often distinguishes "yellows" from the other yellow leaf troubles. The defoliation occurs in one or more waves during June and early July, with the first wave the heaviest and most noticeable. Trees in advanced stages of the disease often drop 50 to 75 per cent of their leaves all at once and yields of such trees are greatly reduced. Affected trees persist year after year with gradual decline.

Control.—Inspection and roguing of nursery stock and newly planted orchards. Spraying will *not* control cherry yellows.

Peach Canker

"Peach canker" has become quite prevalent in many Ohio peach orchards and sometimes causes considerable injury. The fungus causing the disease is a relatively weak parasite which spreads slowly and causes damage in peach orchards as the result of poor orchard practices. The losses from the disease are not spectacular as in the case of brown rot, but rather the result of the accumulative effect of orchard neglect. The application of fungicidal sprays, or dusts will not control the disease. The disease may be eradicated from infected orchards by the employment of good orchard practices for a period of four, or five years as recommended in the paragraph on control methods. The disease is often confused with the injury caused by the "lesser peach tree borer."

Symptoms.—The disease (peach canker) is caused by a fungus *(Valsa sp.)* which enters the trees through weakened, or dead tissues, such as those caused by winter injury, mechanical injury caused by farm

implements, insect injury such as lesser peach tree borer, poor crotch formation, which causes splitting of the tree, and through pruning cuts which have not properly healed. Infection usually takes place in the fall and the fungus develops and injures the tree during the fall, winter, and early spring months. Tree growth in the spring generally outgrows the fungus and the canker injury does not increase until tree growth has slowed in the fall. Cankers occur on the trunk, or large branches, especially in crotches and on injured twigs, resulting in a die-back. The disease is characterized by a sinking of the tissue, followed by the formation of a gum pocket. Later the diseased bark cracks and splits and the gum oozes out in a sticky mass, giving the canker a dark rough appearance.

Control Methods. — Sprays are of little or no value in controlling peach canker, but the following practices have been found to check the disease:

1. Train young trees carefully to avoid narrow, weak crotches.

2. Postpone pruning until very late winter or early spring, at which time all small branches showing cankers and all dead wood should be removed.

3. Make pruning cuts close to branches to promote rapid healing. Large cuts should be protected with a good tree paint.

4. Clean out cankers in crotches and on large limbs during late May and June. Cut around cankered area to green, live bark, making the cuts clean at the sides and bringing them to a point at the top and bottom. Paint the wound with a tree paint in which bichloride of mercury has been dissolved at the rate of 1 to 500 (two 1-gram tablets containing 50 per cent of bichloride of mercury in 1 pint of tree paint makes the desired strength.)

5. Sow a cover crop in the orchard as early as possible to promote proper wood maturity. In young non-bearing orchards the cover crop should be sown as soon as possible after July 1. In bearing orchards sowing of the cover crop can be delayed until about August 1. In any case it is inadvisable to work the ground deeply after this time.

6. Avoid the use of too much nitrogen, especially in young orchards or when the trees are *not* bearing a crop.

7. The control of the lesser peach tree borer is necessary for the control of peach canker, since the disease may enter the trees at any point where the borers have invaded. (See page 57 for control of lesser peach tree borer.)

8. Mechanical injuries caused by farm implements must be avoided in all peach orchards, since any injuries or abrasions produced will allow entrance of the peach canker disease.

Cedar Rust

Cedar rust has become increasingly prevalent on Rome Beauty in southern Ohio. This is a disease that varies a great deal from season to season, and from locality to locality. (See Fig. 41.)

Spores, which infect apple trees, are produced on the cedar trees during rainy periods and are blown by the wind to apple trees, where they cause infection on the leaves and fruit. The apple rust spots on the fruit are orange in color and the small cups of the apple rust fungus may be seen on the spots when mature. Records have been obtained where cedar rust spores have been blown for a distance of 5 miles and produced infection. However, severe infection usually is not accomplished unless the cedar trees are within 3 miles of the orchard. Infection will be more severe when the cedar trees are located near the orchards.

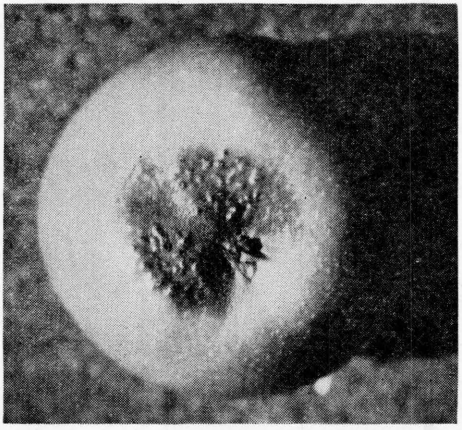

Fig. 41.—Cedar rust.

Varietal susceptibility varies greatly, as indicated in the chart on page 10. Rome Beauty, Jonathan, and Delicious are some of the more susceptible varieties grown in southern Ohio.

If the cedar trees are removed the disease is no longer a factor. If impossible to remove cedar trees, one pound of Fermate per 100 gallons of spray can be *added* in the *pink spray,* see page 4.

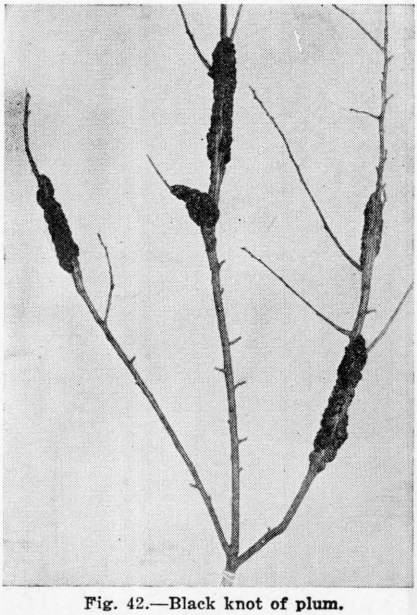

Fig. 42.—Black knot of plum.

Black Knot

Black knot occurs on both wild and cultivated forms of plum and cherry trees. This disease is caused by a fungus, and spores are produced during April, May, and June on the knots formed on twigs and branches. (See Fig. 42.)

Control is obtained by pruning out the knots in the winter and making the cut about 4 inches below the base of the visible swelling.

A second inspection should be made in May and new swellings should be cut out. All pruned wood should be burned immediately.

Codling Moth

Reducing Losses by Orchard and Packing House Sanitation

Orchard sanitation is important as a method of reducing codling moth losses. This includes: (a) elimination of hibernating places such as piles of wood, cut trees, or other debris on the ground, and (b) the prompt disposal of wormy apples. While a sod mulch or cover crop is not utilized freely as a cocooning place, a mulch consisting of cornstalks, wood shavings, or coarse weeds will shelter many transforming larvae.

Thinning operations afford an opportunity to remove from the orchard apples containing first brood larvae. Prompt gathering of worm-infested dropped apples and burying them or otherwise disposing of the same, prevent these worms from adding to the over-wintering population.

Packing house sanitation is very important in orchards where the codling moth is a serious problem. The larvae leave the apples soon after the fruit is placed in the packing house or storage rooms, and crawl into cracks and crevices and into joints of the apple crates. These moths, if allowed to escape, would cause worm-infested fruit within several tree rows of the packing house.

Packing houses and rooms where picking crates are stored should be tightly screened or otherwise kept closed during early summer to prevent the escape of the moths.

Protecting Against Climbing Cutworms

Opening buds of grapes and newly expanded leaves and blossom buds of apple are often devoured in April or early May by climbing cutworms. These feed only at night, and hide under trash on the soil during the day. Unless the grower is keeping close watch, many fruit buds may be devoured, or even an entire crop of grapes destroyed, before the presence of the insect is discovered. (See Fig. 43.)

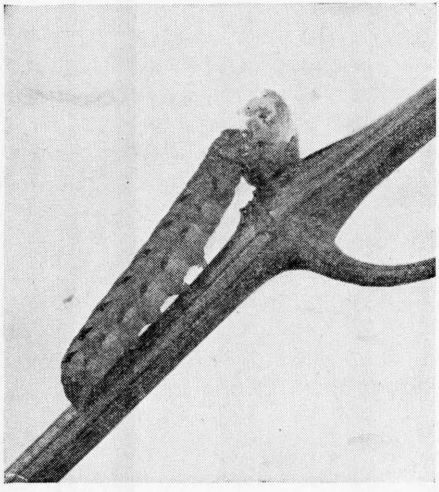

Fig. 43.—The climbing cutworm feeding on grape bud.

Application of a narrow band of sticky tree-tanglefoot on the trunks of fruit trees, and beneath the bottom wire on grape canes and posts in vineyards, will put a stop to this damage. The application should be made as soon as the worms are discovered. They are unable to cross such a band to reach the succulent buds. Many can be

killed by scattering poisoned bran mash bait on the ground. The poisoned bait is dependable only where tanglefoot has been previously applied to prevent their ascent.

While applications of lead arsenate in the pre-blossom spray on apples fail to control, it has been observed that spraying with fluorine spray, as given for apple flea-weevil (on page 8), is a satisfactory method.

Apple Tree Borers

Round-headed apple tree borers make a deep round tunnel into the trunk of the tree, usually near the ground. They attack principally young trees under ten years of age. After the tree comes into bearing, the regular summer spray program seems to keep them under control by repelling the adult beetles.

Infestations of the round-headed apple tree borer must be attacked with reference to the percentage of trees infested. If no more than 5 per cent are being injured, mound all trees in early June and cut out borers in September of each year. If up to 15 per cent are being attacked, wrap the trunks of the trees to a height of 18 inches with stout paper in early June. Put clean earth around the base of each wrapped tree so that borers cannot get to the trunk below the paper. Remove wraps in September.

If more than 15 per cent are attacked wrap and spray the trees in early June and spray again in early July with lead arsenate 3 pounds, lime 3 pounds, water 100 gallons to combat the adult beetles found on the leaves. Inspect young trees each autumn for borer damage.

Tarnished Plant Bugs and Stink Bugs

These sucking plant bugs deform young peaches and to some extent other fruits during the summer. The injury to peaches is shown in Figures 44 and 45.

The most effective control measures for these pests consist in the elimination of such cover crops as alfalfa and sweet clover from the orchard and its vicinity and in reducing as far as possible the amount of weed growth, or tall grass, in the orchard beneath and between the trees.

Recent experiments indicate that a single application of DDT or benzene hexachloride gives good control of tarnished plant bug, if applied at full bloom or shortly thereafter. DDT is slightly more effective than benzene hexachloride in reducing cat-facing. These materials should be used in accordance with the recommendations on peaches in the peach spray schedule (see page 12).

Stink bugs may appear at almost anytime during the summer. If they become sufficiently abundant to warrant special control measures, an application of DDT at the rate of 2 pounds (50% pwd.) in 100 gallons of water would no doubt greatly reduce the population.

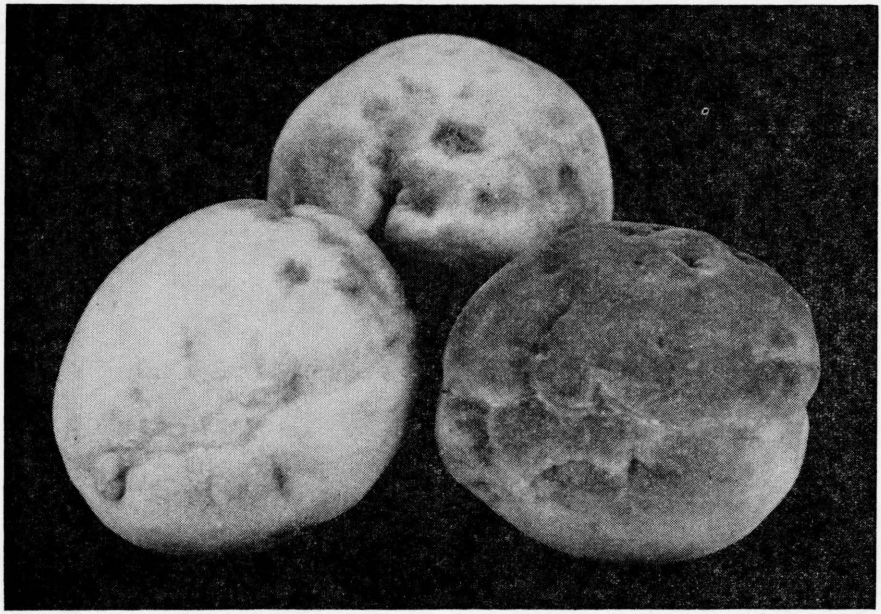

Fig. 44.—Peaches deformed by sucking plant bugs.

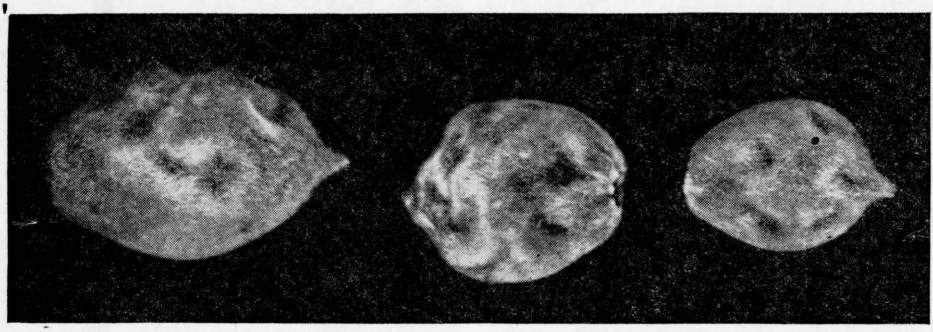

Fig. 45.—Peaches injured in June by the tarnished plant bug, which came from undergrowth

Peach Tree Borers Located at or Beneath Ground

Paradichlorobenzene

This chemical sometimes called P.D.B., Paracide, and by other trade names as well, is now widely used to control the peach tree borer located at or just beneath the ground surface. This material is sold as finely granulated crystals.

Directions for Using Crystal-ring Method.—One ounce of the chemical is advised for treating a full grown tree; from ½ to ¾ ounce around trees from three to five years old, depending upon the size of the trees. Not more than 1½ ounces should be used in any case. Trees less than three years of age can be treated only with the risk of some injury by the chemical. Where borers are present in young trees, lack of treatment will probably result in losses far in excess of any caused by the chemical.

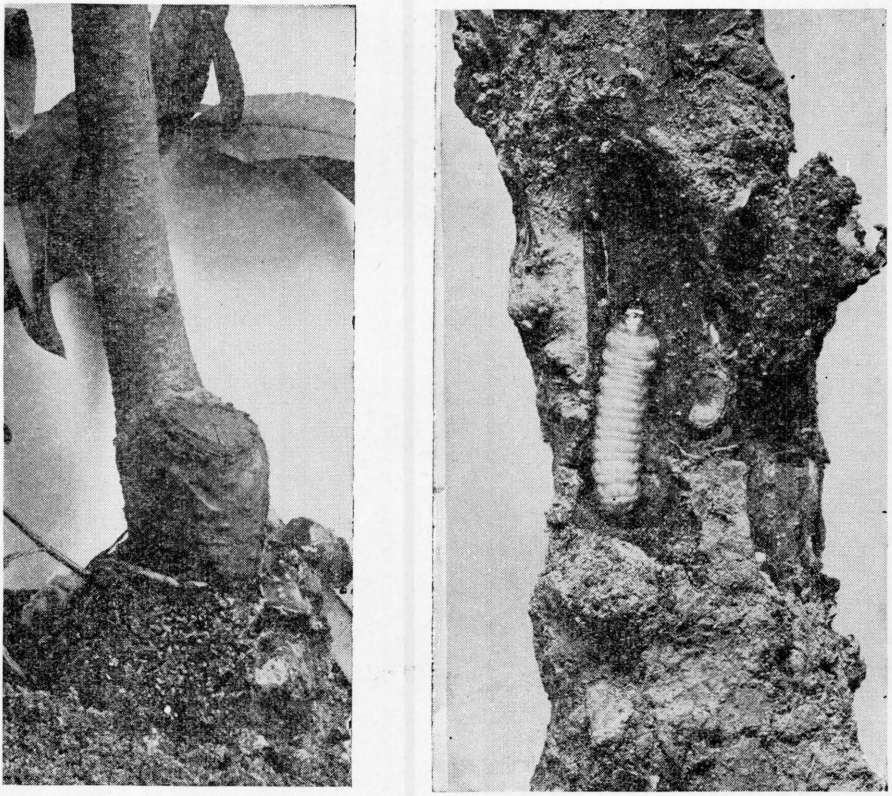

Fig. 46.—The peach tree borer is a serious enemy of young and mature peach trees. The larva bores in the bark and outer sapwood, causing gum to exude near the ground surface.

1.—Apply in the latter half of September in northern Ohio, and the first half of October in central and southern Ohio, when the soil is dry. This will kill the borers while young, and after all eggs are hatched. The temperature of the soil at time of application should be above 55° F. for best results. If fall treatment has not been made and the life of the tree is threatened, a spring application can be made as soon as the soil temperature becomes high enough. This is usually about May 15. Spring applications are never as effective as those made in the fall.

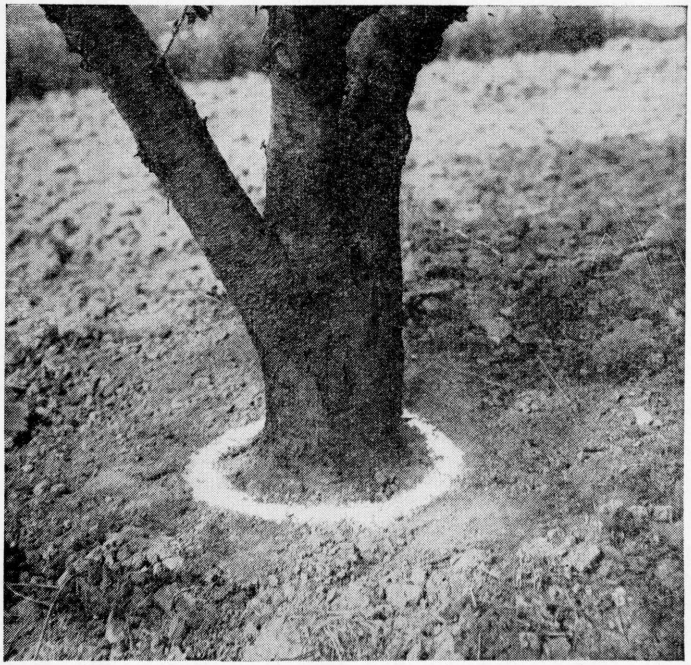

Fig. 47.—Paradichorobenzene properly applied around base of tree, 2 inches from the trunk. Cover the chemical about 3 inches deep with a cone of earth, mounded against tree to confine gas in soil about channels of borers.

2.—Clear off the trash about the base of the tree for a distance of 6 inches from the trunk. Do not dig into the surface crust more than necessary. If considerable gum is present about the base of the tree, remove this before treating. Have the soil surface level with the highest point of gum exudation, and if necessary build up the dirt to this point. The gas given off by the chemical is heavier than air and is most effective below the point of application.

3.—The crystals of paradichlorobenzene are then evenly distributed in a narrow, continuous circular band on the soil about the tree. Place this ring about 2 inches from the trunk. Have the band about 1 inch wide, and none of it closer than 1 inch to the trunk (or large roots), otherwise injury to the tree might result. (See Fig. 47.)

4.—Place several shovels of soil (free from trash) over the ring of chemical. Pour the first shovelfuls of fine soil carefully against the base of the tree. Cover chemical about 3 inches deep with a cone of earth. Compact this with the back of the shovel or with the foot.

5.—*Airing.*—Three to four weeks after application, remove the mound of earth from the base of trees younger than four years. If the soil has been wet, wait from five to six weeks before uncovering. This is a precaution against possible injury to young trees. It is not necessary to remove the mounds from older trees. However, these mounds of earth should be leveled off in the spring to facilitate treatment the next autumn.

A method has been developed whereby the paradichlorobenzene is dissolved in a special commercial oil. This material, known as Para-Scalecide, is convenient to use and is somewhat more effective in cool weather than paradichlorobenzene. If this material is used, the directions on the container should be followed as to quantity and the manner of application and the mounding should be the same as given for the paradichlorobenzene crystals. Do not use the diluted material if the oil separates from the water and rises to the surface.

DDT Sprays

The control measures discussed above have proved effective in killing the peach tree borers that have become established in the trees. This of course results in a smaller borer population and less damage during the following year. However, a method of control is now available which prevents larvae from becoming established in the trees. This consists in maintaining a deposit of DDT on the tree trunks during the period in which eggs are being deposited in order to kill the adult moths and newly hatched larvae.

Such a deposit can be maintained by spraying the trunks thoroughly three times at 20-day intervals, using 4 pounds of DDT, 50 per cent wettable powder, in 100 gallons of water. The first spray should be applied about June 25 in southern Ohio and July 5 in northern Ohio. In making an application, special attention should be given to the base of each tree where the borers usually become established. Weeds, grass, and debris should either be removed from the base of each tree, or covered with spray material, because peach borer eggs are sometimes deposited on such material. The trunks should be sprayed thoroughly.

In orchards where DDT is applied in the second, third, and fourth cover sprays to control the Oriental fruit moth (see peach spray schedule on page 12), two of the applications for peach tree borer may be omitted. If the tree trunks are sprayed carefully when the fruit moth sprays are applied, the only special peach tree borer spray needed is an application to the tree trunks approximately two weeks after the fourth cover spray as indicated in the spray calendar.

For less than 100 trees a hand sprayer may be suitable, but for large peach orchards a power sprayer with a cut-off valve at the base of the spray rod is the proper equipment needed.

Lesser Peach Tree Borers Located on Trunk and Larger Limbs

Fumigating with dry paradichlorobenzene crystals is not possible for controlling the lesser peach borer, which works entirely above ground on trunk and older limbs. (See Fig. 48.) Considerable gum exudation is always found at points of larval feeding, which appear at abra-

Fig. 48.—Work of the lesser peach tree borer in old pruning scars. (For control of this species see page 58. This borer must not be confused with the peach tree borer.

sions on the trunk and in the crotches of the older limbs. Control consists of painting these wounds with crude cottonseed oil in which paradichlorobenzene is dissolved. The cost will amount to less than 1 cent per tree. Painting with ethylene dichloride emulsion is not effective. Under no circumstances should the entire trunk or limb be painted.

Directions for Preparing and Applying Paint. — To prepare the mixture, dissolve 1 pound of paradichlorobenzene crystals in 2 quarts of crude cottonseed oil, previously warmed. Apply this mixture with a paint brush so that the bark is covered well beyond the edges of borer indications. Apply only to the area of the wound. Removal of gum, frass, or loose bark from the infested area is not necessary.

There has been no discernible injury to peach trees so treated, except where the paint has been sprayed or painted over more of the surface than necessary. The application should be made during mild weather the latter half of April or early in October. At this time of year the work of borers is easily visible. Inspection will reveal dead borers a few days after treatment.

It is preferable to use freshly prepared material. If the mixture is stored for a few days, place it in an airtight container. Linseed oil can be used instead of raw cottonseed oil, but it is not so easy to apply, being thicker and more sticky.

The use of organic insecticides applied to the trunks and larger limbs for the control of the lesser peach tree borer is still in the experimental stage. Several of these materials are being tested, but results are not sufficiently conclusive to warrant recommendations.

RODENT CONTROL IN ORCHARDS

The damage done in orchards by such animals as meadow mice, pine mice, and rabbits is extremely costly to many a grower. Much of this damage may be prevented by the use of inexpensive control methods and variations in cultural practices.

Mouse Control

The mice which cause most of the damage in all but the southern part of Ohio are the meadow mice *(Microtus)* (Fig. 49, right). This small creature lives primarily on the surface of the ground, making trails under the cover of surface vegetation. Most of the damage is done by feeding on the bark around the trunk of the tree.

In southern Ohio, the most troublesome mice are the pine mice *(Pitymys)* (Fig. 49, left). These mice spend most of their lives below ground, and during certain months have a particular fondness for apple tree bark, which they eat from the roots.

Trees may be partially protected from meadow mice by use of ¼-inch mesh galvanized hardware cloth. However, during heavy snows, mice may tunnel through the snow and do damage above the wire guards. Also, during mild winters, mice may tunnel through the frost-free soil and do damage below the wire guards.

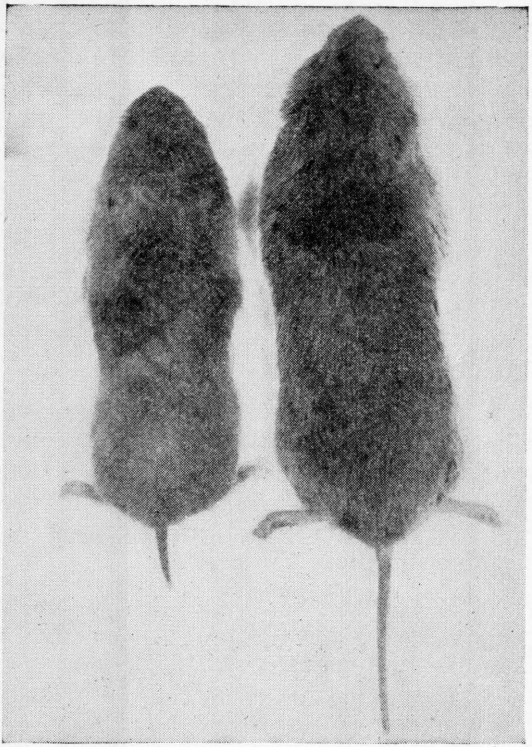

Fig. 49.—*Left*: Pine mouse, small body, short tail, sunken eyes, burrows underground. *Right:* Meadow mouse, large body, long tail, prominent eyes, makes surface trails.

Keeping mulch and other vegetative material removed from around the tree base gives partial protection when there is no snow on the ground, because these mice seldom feed in the open. A clear space of aproximately 18 inches should be made around the tree trunk. The use of cinders, slag, sand, sawdust, etc., may be used to keep grass, etc., from growing in this area. If cinders or slag are used, caution should be taken to use well leached material to avoid injury to the tree by chemicals.

These preventive methods give only partial control for meadow mice, but for pine mice there are no known cultural methods which prevent mouse damage. *The use of poisons is the most efficient and practical method to control mice and should supplement all other methods.*

The Rodent Control Division of the Fish and Wildlife Service, U. S. Department of the Interior, has developed a satisfactory control method. The poison material (rodenticide) in which zinc phosphide is incorporated and recommendations for its use is made available through the U. S. Fish and Wildlife Service and its cooperating agencies, which in the counties is the County Agricultural Agent. The poison is used on fresh baits which are placed directly in active mouse runways and then covered with grass or similar material. The following directions are recommended:

Time of application.—Poisoning in the fall, well carried out, usually makes poisoning in orchards at other seasons unnecessary. Where poisoning has not been carried out in the fall, or where follow-up work is required, emergency poison methods may become necessary at any season. Examine orchard during open periods in mid-winter to check on inefficiency of fall control. Re-poison *if* and *where* necessary. Apple baits should not be used in late fall until drops have been gathered.

FIG. 50.—Young apple tree damaged by meadow mice.

Bait. — Cut apples into ½-inch cubes. Firm, ripe varieties are preferred. One quart of cubes should make 100 baits. One man can expose about 5 quarts each morning. Expose only freshly cut baits.

Preparation.—Place about 2 inches of cut apple bait in the bottom of an enamel pan. Sift zinc-phosphide rodenticide over the bait while stirring until an even light coating is obtained. The use of 1 level teaspoonful per quart of cut bait is sufficient.

Caution.—Trust the mixing only to responsible persons and wash all utensils after preparation is completed. Do not use bare hands in mixing or placing baits. A sharp stick is convenient to spear and place the baits.

Exposure in Orchards. — Fresh apple bait must be placed directly in mouse trails *UNDER COVER* of mulch, or in burrows that enter the ground. Select clear, quiet, warm days (for the time of year) and place the baits early in the day, since afternoon is the most active period of the day for the mice. Use only one cube in a spot and make several placements about each tree, depending upon the number of trails and holes observed. First survey entire orchard to locate most heavily infested areas and bait these first very thoroughly. Then bait as needed outside these infected areas.

Important: Place so that other animals or birds will not reach the toxic baits.

Growers can also use strychnine coated grain and place in the mouse trails as previously discussed. After freezing weather occurs a spoonfull of strychnine coated grain next to an apple bait in the runway or hole may improve control.

RABBIT CONTROL

In some parts of Ohio, damage done by rabbits to young apple trees and other tender fruit stock is severe.

Wire guards give some protection except during periods of deep snowfalls. Other protectors such as heavy paper, burlap, wood veneer,

etc., offer the same protection as wire guards but are less permanent. Scattering small piles of freshly cut succulent prunings in the orchard before damage is done diverts rabbits from feeding on tree trunks.

Many commercial repellents are on the market and some home-made preparations have been used with partial success varying with climatic conditions and rabbit populations. A very effective repellent paint, 96a, is available from the Rodent Control Division of the U. S. Wildlife Service. The paint described below has been used with considerable success by many Ohio orchardists.

Home-Made Rabbit Paint.—Use rosin and ethyl alcohol in the proportion of 1 pound of powdered rosin to 1 pint of alcohol. Denatured methyl alcohol is not satisfactory, as it will not dissolve the rosin. Warm the rosin over a slow fire just to melting point but do not superheat it. Heat the alcohol to about the temperature of the rosin. Do not heat the alcohol over a direct flame, but warm it in a pan or bottle immersed in hot water. Add the heated alcohol to the melted rosin and stir to an even consistency. If the rosin is too hot the alcohol will bubble and escape. Immediately place the preparation in a container that can be corked or sealed and keep sealed, except when in use. Keep snow and rain water out of the preparation, as moisture changes the texture of the paint.

Apply with a brush when bark is dry. Cover bark or trunk and lower limbs as far as rabbits can reach. Allow for snow which may permit rabbits to work higher on the trees.

Rosin-alcohol rabbit paint covers easily and is economical. It has been used extensively under Ohio conditions and found safe and effective in preventing rabbit damage. It is best to make first application in early fall before any damage has occurred and repeat in midwinter or later as needed to maintain effective coverage.

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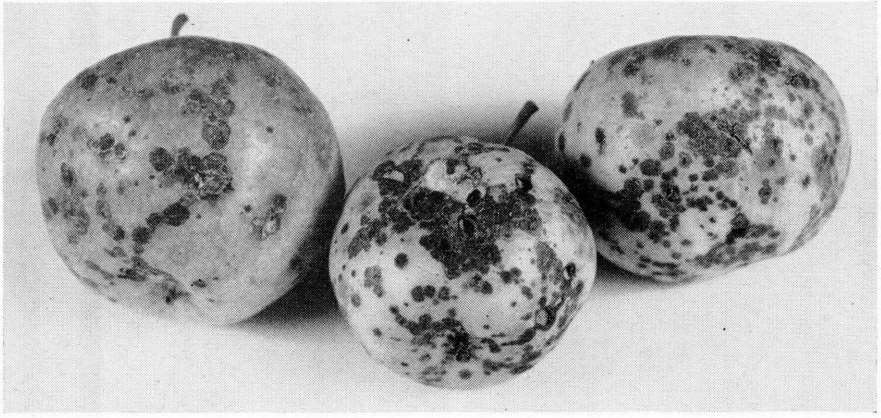
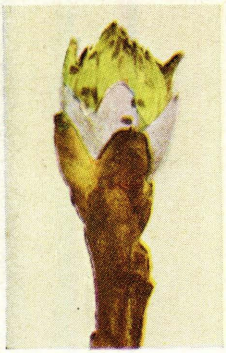
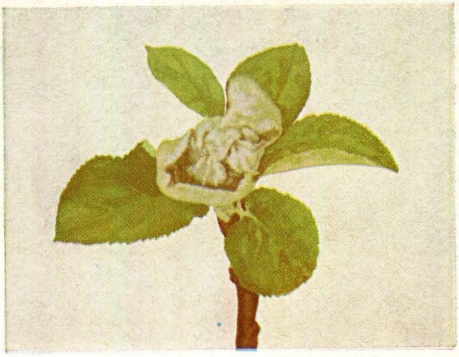


Fig. 51.—Apple scab.
(Major disease of apples)



DELAYED DORMANT

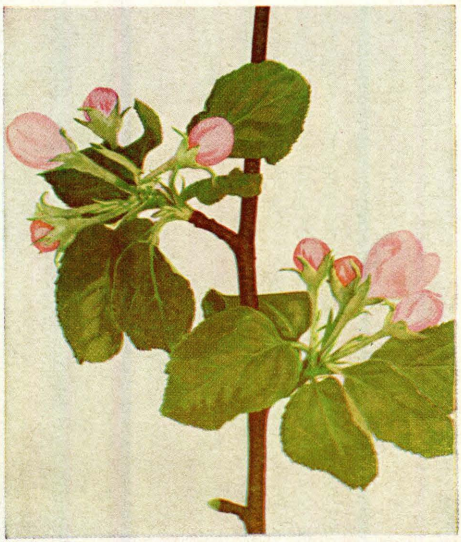
LATE DELAYED DORMANT



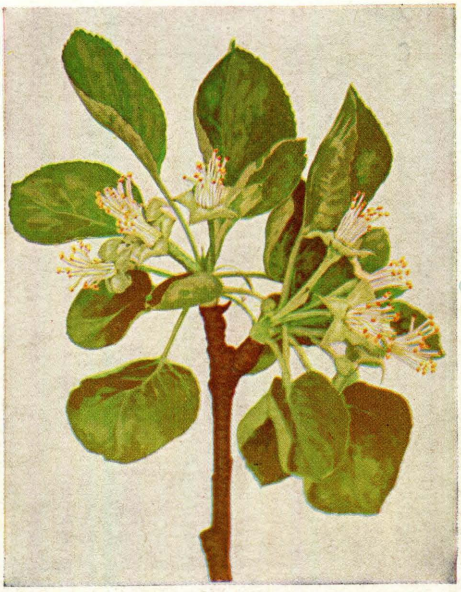
EARLY PRE-PINK

PRE-PINK

PINK



FULL PINK



CALYX CUP